Northern Territory

Department of Business, Industry and Resource Development

Primary Industry Group

Technical Annual Report 2001/2002

DISCLAIMER

Berrimah Agricultural Research Centre
Makagon Road
Berrimah NT 0828
GPO Box 3000
Darwin NT 0801
Tel: (08) 8999 2313

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INTRODUCTION

As part of a major restructure in the Northern Territory Government, the Department of Primary Industry and Fisheries became part of a larger organisation that also includes the former Departments of Mines and Energy, Industries and Business, and Asian Relations and Trade. The name of the expanded organisation is the Department of Business, Industry and Resource Development.

This Technical Annual Report presents a summary of results of research and development work carried out by staff of the Primary Industry Group, covering the Pastoral, Horticulture and Resource Protection Divisions.

The Fisheries Group is reporting its research and development information for 2001 separately in *Fishery Status Reports 2001,* (Fishery Report No. 65), which is available from the Publications Section.

The pastoral industry continued to enjoy good conditions in 2001/02. Rainfall was low in some areas, but demand and prices for live export cattle remained high.

In 200 pastoral leases, the pastoral industry manages close to half of the land mass of the Territory. The management of this vast land involves major responsibilities such as the control of pests, weeds and bush fires. It also requires pastoralists to be aware of important environmental issues. Apart from providing direct employment to about 1,500 Territorians, the industry generates considerable income and employment in various support sectors of the economy.

While the pastoral industry is pursuing increased production to meet demand from wider markets, it is also focusing on protecting the environment. Some large pastoral companies have dedicated environmental officers who monitor the condition of their properties. At the same time, many members of industry are active in the Landcare movement.

Meat and Livestock Australia is forecasting an increase of 9% in the Australian live cattle export trade, to reach 925,000 animals in 2002/2003. The Territory's share of this is expected to grow by 10% in 2002/2003 to reach 231,000 animals. Indonesia and the Middle East continue to be the main markets.

In the agricultural sector, hay continues to be the main crop. The Peanut Company of Australia continued developing its NT operations and purchased a Katherine property for producing peanuts.

Horticultural production increased in 2001 by 5.4% compared with the previous year, to reach $92.2m.The gross value of the fruit industry increased by 0.6% from $70.8m in 2000 to $71.2m in 2002. The volume increased by 5.7% from 24,641 tonnes in 2000 to 26,038 tonnes in 2002. In terms of production and value, the most significant increases were in table grapes, rock melons, water melons and other fruits such as jackfruit and dragon fruit. The gross value of mangoes declined by 11.8% from $35.6m in 2000 to $31.4m in 2002, while volume decreased by 12.8% from 11,952 tonnes in 2000 down to 10,427 tonnes in 2002.

The value of table grapes increased by 11.7% from $18.0m in 2000 to $20.1m in 2001 and production increased by 33.3% from 3,000 tonnes to 4,000 tonnes over the same period. The value of bananas decreased by 8% from $13.0m in 2000 to approximately $12.0m in 2001 while production decreased by 8.8% during the same period.

The value of vegetables during 2001 was stable, registering a small increase of 1.6% from $10.9m in 2000 to $11.0m in 2001. There were major increases in the production of cucumbers, basil and other herbs and exotic leafy vegetables. Total vegetable production increased by 10.9% from 4,207 tonnes in 2000 to 4,667 tonnes in 2001.

The Darwin region is renowned for supplying new, unique and a diverse range of tropical cut-flowers. Heliconia and ginger cut-flowers continued to increase in production and still dominate the flower industry.

PASTORAL

PROGRAM: Agricultural Development

SUBPROGRAM: Pasture Development

Objective:

Expand the industry base through increased areas of pasture and expansion of industry skills and experience in managing pastures.

Outcomes

Expansion of the industry through increased pasture production.

Continued support of forage research and demonstration programs aimed at increasing the supply of hay to the emerging forage cube industry.

Overview - 2001/02
The wet season opened in November with good rain across the Darwin District. December rainfall was generally low and erratic. This pattern continued during January. There was a good monsoonal spell in early and mid February, which was followed by good falls during late February up to mid March. After mid March, rainfall events were again light and erratic, and were separated by dry spells of a few to many days.

The rainfall for the wet season was about two thirds of the average. Most of the wet season was dry, with much of the significant rain falling during one monsoonal spell in February.

The lower rainfall reduced pasture yields across the district, but yields were still good as the spaced rainfall events kept the grasses green and growing. At the end of the wet season, pasture growth stopped quickly and the pastures dried out rapidly because of the lack of soil moisture. This led to an earlier burning season than in recent years.

The floodplains did not flood for an extended period during this wet season, and dried out earlier than in recent years. This allowed stock access to the floodplains earlier than in recent years, but similar to access in a "normal" wet season.

Demand for extension/information on pastures and seeds continued to increase at record levels during the year, exceeding previous years and approaching 400 enquiries.

PROJECT: Increase of Early Generation Seed of Released Pasture Cultivars

Project Officers: **B. Ross, G. Hore and A. Cameron**

Location: Paddocks 8 and 9 Berrimah Farm

Objectives:

To evaluate new lines in a confined non-grazed environment.

To bulk-up seed from promising lines for further evaluation.

To bulk-up early generation seed of pasture cultivars released in the NT.

Project Period: 2001-2006.

Method:

Small areas of cultivars released in the Northern Territory are maintained in Paddock 8 and Paddock 9. Seed harvests are organised as required to ensure that fresh early generation seed is available.

Annual species are grown for seed and harvested as required.

Weed control was undertaken on the Arnhem pre-basic seed area. An area of Cavalcade was planted into weed mesh in Paddock 8 to produce prebasic seed.

Results:

No harvests were undertaken in 2001/02.

The seedlings were subjected to severe grazing by Magpie geese, which reduced yield.

PROJECT: Assessment of Newly Released Australian Pasture Cultivars under NT Conditions

Project Officers: **B. Ross and G. Hore**

Location: Berrimah Farm

Objective:

To determine if forage cultivars released commercially elsewhere in Australia are suitable for use in the NT.

Project Period: 1999-2002

Background:

While many pasture, hay and forage cultivars released commercially in Queensland are suitable for use in the NT, some are not by virtue of their time to maturity, lack of dry season drought tolerance or high soil nutrient requirements. As most are marketed widely throughout northern Australia, it is necessary that new releases be evaluated under Northern Territory conditions. From time to time, industry interest in "old" cultivars requires evaluation or re-evaluation of cultivars.

Method:

Newly received seed is grown in a confined non-grazed environment, for evaluation and to multiply seed for further evaluation.

The 1998/99 sowings included:
Bambatsi panic *(Panicum coloratum var. makarikariense)* cv Bambatsi (also known as Makarikari grass). Bambatsi panic has been the subject of recent interest and experimental and commercial sowings as a component of the pasture rotation phase on grey clay cropping soils in 600 - 750 mm rainfall areas of Queensland. Bambatsi had grown well but by June appeared to have run out of nitrogen.

Paspalum atratum cv Hi Gane is the Australian release of the US cultivar "Suerte" which is used extensively in Florida. Hi Gane was released in Queensland in 1998 as a potential pasture grass for the Queensland coastal region. A similar *P. atratum* accession ATF1054 has persisted and grown well at Berrimah. This seed did not germinate.

Paspalum nicorae cv Blue Dawn is being marketed in southeast Queensland as a turf/ground cover. Blue Dawn grew well but produced little seed.

Aeschynomene villosa cv Reid is the early maturity component of the commercial seed mix "Villomix". It is being evaluated in the NT as one of a number of legumes, which may have potential as pasture or ley legumes in newer intensive agricultural areas of the NT, such as the Sturt Plateau. Growth at Berrimah Farm has been only fair to good.

Urochloa mosambicensis cv Saraji was developed at Saraji mine in central Queensland as a ground cover species for revegetation but may also be useful as a grazing plant in lower rainfall environments than the existing sabi grass cultivar, Nixon*.* Saraji had poor ground cover and less vigour than Nixon did at Berrimah Farm.

1999/2000 sowings include
Repeat sowing of Hi Gane. Hi Gane made considerable vegetative growth but did not flower due to late planting out.

Dicanthium aristatum cv Floren grew quickly and produced moderate amounts of dry matter.

Bothriochloa bladhii subsp glabrata cv Swann did not germinate.

Results 2000/2001:

Of the 1998/99 sowings, *Paspalum nicorae* cv Blue Dawn, *Aeschynomene villosa* cv Reid, *and Urochloa mosambicensis* cv Saraji, only Blue Dawn continues to impress. Saraji has spread slowly but produces little dry matter. Reid has re-established from seed but is not outstanding.

Results 2001/2002:

No new sowings were undertaken this year. *P. genourum* was removed during the 2001/2 wet season.

Other existing sowings
Plots of Jarra (*Digitaria milanjiana* cv Jarra), Arnhem (*Digitaria swynnertonnii* cv. Arnhem), *Panicum maximum* C1, *P. nicorae* and *P. atratum* have been maintained.

PROJECT: Assessment of Pasture Cultivars on Pre-Release in Queensland

Project Officers: B. Ross and G. Hore

Location: Berrimah Farm

Objective:

To determine if forage cultivars intended for release commercially elsewhere are suitable for use in the NT.

Project Period: 1999-2002

Background:

Because of some similarities in climate and industry in parts of Queensland and the NT, the results of plant evaluation programs in Queensland may be of relevance to NT producers. By evaluating potential cultivars, which have reached the pre-release stage of evaluation elsewhere, we can gather sufficient information to determine whether these plants have a role in the NT before they come on the market.

Method:

Newly received seed is grown in a confined non-grazed environment, for evaluation and multiplication for further evaluation.

The 1998/99 sowings included:

Paspalum nicorae CPI 27707 along with CPI 21370 (now cv "Blue Dawn") which were placed on pre-release in Queensland in 1991. They are being considered in southeast Queensland as potential high use pastures with weed competition abilities and for amenity planting.

Arachis pintoi ATF 2320 is a high quality, high yielding forage peanut.

Results 1998/99:

Both *P. nicorae* lines established and grew well.

A. pintoi was not planted out due to difficulty in germination and subsequent late release from quarantine.

Results 1999/2000:

Both *P. nicorae* lines grew well but produced little seed.

A. pintoi was the only Arachis at Berrimah Farm to survive four weeks of continuous rain and saturated soil. It has grown and spread under dense grass cover of *Urochloa* spp.

Results 2000/20001:

As before, both *P. nicorae* lines grew well but produced little or no seed, while *A. pintoi* survived.

Results 2001/2002:

A.pintoi has spread under grass during the year and spread from two plants to cover an area of 5 $m^{2.}$

PROJECT: Evaluation of Short Season Legumes

Project Officers: B. Ross and G. Hore

Location: Berrimah Farm

Objective:

To evaluate a range of early-maturing forage legumes for their potential use as pasture or ley cultivars in regions of the NT receiving less than 900mm annual rainfall.

Project Period: 1999-2004

Background:

As more intensive agriculture extends into lower rainfall areas of the NT, there is a need for hay crops and ley legumes suitable for that environment. Cavalcade, the predominant hay crop in the NT, is limited by its relatively late flowering time to regions with a wet season of at least five to six months, which makes regeneration from seed in a dryland situation risky in areas south of Katherine.

Method:

The first phase of the evaluation is to multiply scarce seed to obtain enough to conduct regional evaluation. At the same time the accessions are screened under favourable conditions (irrigated and fertilised) and those which are obviously unsuitable are eliminated from further evaluation.

Small quantities of seed received from interstate researchers were germinated in a seedling mix in the shade house and transplanted to the field as spaced plants at four to six weeks of age. Thirty three accessions from the genera *Aeschynomene*, *Arachis*, *Centrosema*, and *Desmanthus* were received; 30 made it to the field as three of the first sowings of *Arachis* failed to germinate, most likely due to the age of the seed, which was10 years.

A series of measurements is taken monthly throughout the growing season. Seed is being collected, cleaned and stored.

Results 1999/2000:

Arachis monticola CQ 990 again died back during the wettest month of the wet season. As it did last wet, it has regrown or re-established from seed but growth has been only poor to fair.

All *Aeschynomene americana* lines grew well with the exception of 93579, which was only fair. A number plants were destroyed by termites, pre-flowering and all suffered from powdery mildew in the late wet and early dry season.

A. histrix growth ranged from poor to very good (93595).

A. villosa growth ranged from poor to good (86163, 91082, and 90897). The cultivar Reid has been only fair.

All *C. pascuorum* lines had good or very good growth except 91318, which was only fair. CPI 65950 grew less vigorously than in 1998/99 and appeared to suffer from a nutrient deficiency. This line was promising in early evaluation of ley legumes in Queensland.

Results 2001/2002:

A. monticola has survived and spread from two plants to an area of 3 m^2 despite dying back in the wettest period of each year.

All *Aeschynomene* lines were terminated in 2001 and regrowth of seedlings was sprayed during 2002.

C. pascuorum lines suffered severe grazing by magpie geese during the early-mid wet season but recovered in time to flower and seed. Seed production was highly variable. Most lines produced 100-200 g of seed from a 5-m row in both 2000 and 2001. The late flowering CPI 92949 consistently produced over 800 g of large seed, while 94300 and 88459 produced over 350 g of seed when insects were controlled.

PROJECT: Gamba Grass Mapping

Project Officer: B. Ross

Location: Darwin and Katherine Regions

Objective:

To map the results of gamba grass surveys undertaken by Weeds Branch, Agriculture Branch, and Specialist Weed Control Pty Ltd.

Project Period: 1999-2004

Background:

In the last two years several groups have surveyed gamba grass occurrence along roadsides in parts of the Top End. Many individuals and organisations have expressed interest in the results of these surveys.

This small project was undertaken using ArcView 3.1 to see if the various surveys could be reconciled and to provide a visual record of the gamba grass survey and control demonstration project.

Progress:

A poster of preliminary results was presented at the NARGIS'99 Conference. Progressive results of the 1998 and 1999 surveys were presented at workshops in October 1999 and March 2000. A limited repeat survey was carried out during 2001 and maps were updated to reflect the results.

The Stuart and Arnhem highways were re-surveyed in detail in 2002.

PROJECT: Characteristics of Tropical Floodplain Grasses

Project Officers: B. Ross and G. Hore

Location: Berrimah Farm

Objective:

To document growth and seed production of common native perennial floodplain grasses found in the Darwin region, and provide a nursery of plant material for further experimentation.

Project Period: 2001-2004

Background:

There is considerable interest in the potential use of native floodplain grasses for revegetation following the control of *Mimosa pigra* and for grazing as an alternative to exotic grasses. For this to be practical, a ready supply of seed or vegetative planting material is required.

Method:

In December 2000, runners of *Hymenachne acutigluma*, *Pseudoraphis spinescens* and *Leersia hexandra* were collected in the field and transplanted to Paddock 1 at Berrimah Farm. Plants have been maintained throughout the year under drip irrigation. Seed of H. *acutigluma* is collected weekly. Seed of *L. hexandra* is collected opportunistically, while *P. spinescens* has not produced seed. All species continue to grow and spread vegetatively throughout the year.

From a 20-m row of *H. acutigluma,* 6 g of seed was collected through weekly hand harvests. Runners produced during the 2001 wet season died back during the dry season, and a number of original plants appeared to have died and were replaced by new plants established along runners. These new plants remained very small. *P. spinescens* flowered profusely in November 2001 but few caryopses were found. Occasional flowers were observed on *L. hexandra*, which readily produced 2-3 m long runners whenever moisture was available to the parent plants. When adequate soil moisture was available, runners rapidly produced roots at nodes, but died back when the surface soil dried out. *P. spinescens* runners spread on average about 60 cm from the parent row, and survived limited rainfall and hot conditions in October and November.

PROJECT: Assessing the Potential of Native Grass Species for Revegetation of Tropical Wetland Habitats

Project Officers: A. Cameron, G. Hore, B. Ross and B. Beumer

Location: Berrimah Farm and Mary River District

Objective:

To identify the most efficient and effective methods of collecting, processing and storage of seed of native perennial floodplain grasses.

Project Period: 2001-2002

Background:

There is considerable interest in the potential use of native floodplain grasses for revegetation following control of *Mimosa pigra*. For this to be practical, a ready supply of seed is required, and methods need to be developed to harvest, clean, test and store seed of the main floodplain grasses.

This is an NHT Bushcare funded cooperative project between Agriculture, Weeds Branch and Greening Australia staff.

Method:

A brush harvester was constructed to fit onto the Weeds Branch airboat to harvest seed of *Hymenachne acutigluma*, *Leersia hexandra* and *Pseudoraphis spinescens* in standing water. These grasses produce seed mostly during the wet season when they are accessible only by boat or airboat.

Progress:

The construction of the brush harvester took longer than anticipated, as "new" ideas were needed to reduce the weight of the unit and to improve the control of speed of the airboat.

A frame is being constructed to allow the brush harvester to be used in shallow water by towing with a small tractor or quad bike.

As the floodplains dried out earlier than anticipated this year because of the low rainfall in the wet season in the Top End, the brush harvester will be demonstrated on the floodplain at a field day during November/December of 2002.

PROJECT: Seed Testing Laboratory

Project Officers: A. Simonato and A. Cameron

Location: Berrimah Farm

Objective:

To provide an accurate and reliable seed testing service to the pastoral industry, Government and the public in the NT.

During the year 364 consignments were submitted for testing. The number of Quarantine lots has decreased this year, with Quarantine Officers identifying and releasing seed at the various collection points. The Seeds Laboratory is now registered by AQIS as Commercial Premises and AQIS is being charged for services.

The following tests were carried out on the submitted lots.

Test	No. of tests
Certification	1
Purity	27
Germination	185
Bulk search	9
Quarantine inspection	233
Quarantine identification	260
Comparative test	5
Tetrazolium test	4
Export examination international	6
Export examination interstate	123
Seed count	1
Identifications	3
Seed cleaning	1
Total	**861**

Other seeds matters

Seed certification applications were made for 227 hectares during the 2001/02 wet season. This was almost double the area for the previous year. A total of 52.8 tonnes of seed was certified during 2001/2002. Most of it was Cavalcade and Bundey.

A. Cameron inspected six snake bean lines from Quarantine, for release to Plant Pathology.

The Seed Reference Collection had 290 new seed samples added.

Indonesian feed samples are being checked for the presence and viability of weed seeds prior to the import of feed pellets.

A. Simonato and A. Cameron conducted a Seed Samplers Course for eight industry and four departmental staff.

SUBPROGRAM: Agriculture and Irrigation Development

PROJECT: Irrigated Maize Production on Blain Soils at Douglas Daly Research Farm

Project Officers: **F. O'Gara, S. Lucas, C. Ham and M. Hearnden**

Location: Douglas Daly Research Farm

Objective:

To determine the yield potential and agronomic requirements of irrigated maize in the Daly Basin.

Background:

Irrigated maize is still a minor crop in the NT but one of the few field crops, which lends itself to centre pivot irrigation in the dry-season. It is a suitable rotation crop with peanuts and capable of producing high yields and moderate to good returns. However, there is still only a small local market for maize grain. There may be potential to develop the market in line with demands for stockfeed for the live cattle trade. Commercial maize yields have been disappointing due to inexperience and inadequate inputs. With the increasing demand for stock feed for the live cattle trade there is increasing interest in maize as a silage crop.

There is a need to evaluate the potential of irrigated maize both as a grain and silage crop in the Top End. The objective of the work is to identify suitable commercial varieties, develop an understanding of the crop's specific requirements and provide producers with an agronomic package of information for growing maize in the Top End.

Method:

Nine commercial varieties were sown in a conventionally prepared seedbed on 10 April using a Nodet Gougis precision vacuum planter under the centre pivot at DDRF. Trial design was a randomised complete block with four replicates with plot sizes of 150 m long by four rows. The total area planted was approximately 5 hectares. Leaf samples were taken 35-40 days after sowing (DAS) and at silking to determine plant nutrient content. Yields were measured using an International 1420 header.

Fertiliser is applied pre-plant, at planting (banded) and by fertigation. The trial crop receives approximately 280 kg N, 40 kg P, 150 kg K, 33 kg S, 64 kg Mg, 20 kg Zn and 1.5 kg B depending upon soil analysis. Zinc and Mg are applied at high rates initially to avoid deficiency. Subsequent Zn and Mg applications are reduced. Average plant populations are between 75,000 and 84,000 plants per hectare.

An Environscan® soil moisture-monitoring system and Jet-Fill® Tensiometers monitor irrigation and soil moisture content. The crop received between 4.0 and 5.0 ML/hectare of water. Weeds are controlled by a post-plant, pre-emergent application of Primextra® (atrazine plus metolachlor). Recommended insecticides control insects such as armyworm, *Helicoverpa* spp. and green vegetable bug when threshold populations are reached.

An Insectigator III® chemigation unit was installed on the centre pivot in 2001 to evaluate the efficacy of applying pesticides through irrigation water. The unit injects precise amounts of the required chemical directly into the centre pivot. A non-return valve was fitted to the input line of the pivot to prevent chemicals entering the main supply line.

Gaucho® (imidacloprid), a newly developed systemic chemical in the nitroguanidine group was evaluated as a seed dressing for leafhopper and wallaby ear virus control in 2001. A control area was established adjacent to the main variety trial to compare the efficacy of Gaucho®.

Results and Discussion:

The yields from the respective varieties are shown in Figure 1. Yields are corrected to 12% moisture.

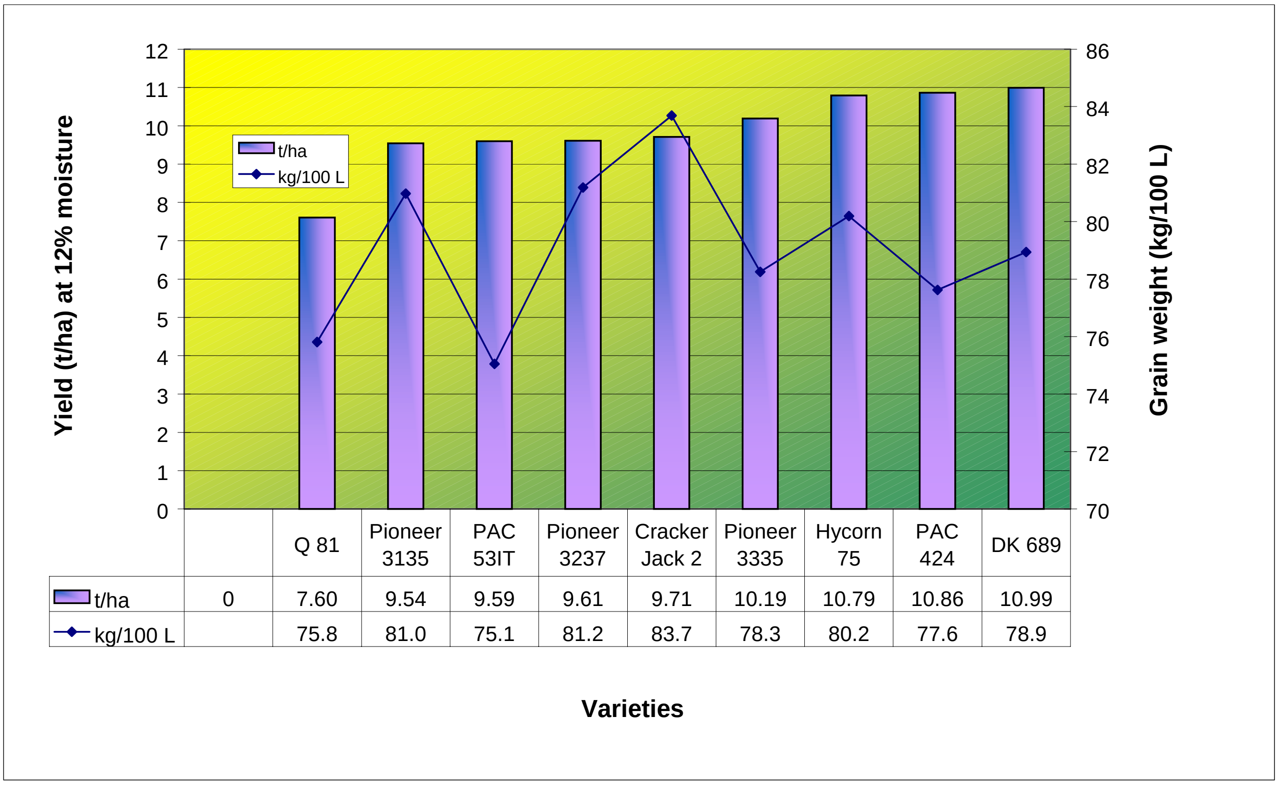

Figure 1. Irrigated maize yields at DDRF 2001 dry season

Table 1. Analysis of variance of variety effects

Summary of all Effects; design: (maize)					
1-Variety					
df	MS	df	MS		
Effect	Effect	Error	Error	F	p-level
8	4.304655	27	0.238846	18.02269	5.7E-09

Analysis of variance showed that there was a significant difference between varieties. Q81 had a significantly lower yield than all other varieties. DK 689, Pacific 424, Hycorn 75 and Pioneer 3335 were the highest yielding, respectively and did not differ significantly. Most of the other varieties (excluding Q81) did not differ significantly from Pioneer 3335, which yielded over 10 t/ha. This trial indicated that most varieties were capable of producing 10 t/ha or more under local conditions, which is considered a viable maize yield. DK 689, Pioneer 3237 and Hycorn 75 have been consistent performers over the past three years. These trials indicate that potential maize yields should be around 9.0 to 10.0 t/ha using the best varieties. At these yields maize has a potential gross margin of between $829 and $1100 per hectare. The grain weight varied considerably depending on variety with little relationship between grain weight and yield.

Lodging was visually rated from 1 to 5 (i.e. from mild to severe). Cracker Jack had the highest lodging score of 2.6 followed by DK689 and Pioneer 3237 with a score of 1.63. Most of the other varieties had low ratings for lodging.

Insect management

Gaucho® provided excellent control of leafhopper and protection against wallaby ear virus (WEV). The control area was severely affected by WEV. Affected plants were stunted with dramatically reduced stalk length, leaf area and root development. Yield from severely affected plants was less than half of the treated area. The treated area had a lower number of leafhoppers and no visible disease symptoms. Gaucho® as a seed treatment eliminated the need to apply post emergent insecticides to control leafhoppers. Up to three chemical applications were required in some seasons to control leafhoppers. Gaucho is now recommended as a seed dressing for maize crops in the NT.

Table 2. Effect of Gaucho® on leafhopper number

	Control	Gaucho treated
Leafhopper No./10 m row*	94	5

*Average number from vacuum sample

The Insectigator III® chemigation unit was used to apply various chemicals and biocides to control a range of economically damaging pests. Gemstar® (active constituent: nuclear polyhedrosis virus) and DiPel Forte (active constituent: *Bacillus thuringienesis* var *kurstaki)* were applied through the insectigator to control armyworm and *Helicoverpa* spp. Chlopyrifos and one synthetic pyrethroid was applied prior to silking and at early grain fill, respectively, principally to control the green vegetable bug. Gemstar® appeared (observation only) to be more effective in reducing larvae numbers than Dipel®. However both products require further evaluation under local conditions. The improved insect control is reflected in improved yields in the 2001 season.

The insectigator improved the over-all pest management of the crop compared to previous seasons. While chemigation requires further refinement in terms of timing of application and selection of product, there are major advantages in the system over aerial or ground based applications. Chemigation allows the chemical to be applied at the optimum time, increasing the efficacy of chemicals and thereby reducing costs and chemical use. It also facilitates the use of more specifically targeted bio-pesticides of low toxicity, which do not affect naturally occurring beneficial insects.

PROJECT: Producer Initiated Research and Development Project (PIRD) - Evaluation of Wynn Cassia as a Pasture and Fodder for the Douglas Daly Area

Project Officers: **Douglas Daly Producers Group, F. O'Gara (Coordinator) and DBIRD Staff**

Location: Commercial Farms, DDRF and BARC

Objective:

To determine the productive capacity of Wynn Cassia as a pasture and fodder species in commercial enterprises in the Douglas Daly area.

Background:

Wynn Cassia, also known as Roundleaf Cassia (*Chamaechrista rotundifolia*) is an exotic legume, which was introduced as a pasture over 20 years ago. It is a prolific seeder and invades new ground rapidly. It dominates pastures because animals select more palatable species and leave it until later in the season. Despite its presence and dominance in many commercial pastures, there is no hard data on how well cattle accept and perform on Wynn Cassia in the NT. There is little information on its ability to fix nitrogen or its role in sustainable grazing systems in the Top End. Its contribution to overall productivity needs to be quantified under NT conditions. Some producers, while continuing to sow it still cannot quantify its value. Other producers are reluctant to plant it due to its tendency to dominate the sward at the expense of more palatable grasses. There is genuine fear that Wynn may become too dominant and reach weed status in the area.

PIRD projects are an initiative of Meat and Livestock Australia. PIRDs provide a mechanism by which producer groups can access funding to target issues, which affect local production systems and businesses.

The Douglas Daly PIRD project was started in July 2001. Producers decided there was a need to establish better information on Wynn Cassia and determine whether cattle actually performed well on it and under what conditions. Producers nominated a range of issues they would like answered and also initiated a number of activities that would lead to better knowledge of the species and its benefits as a pasture and fodder crop.

As part of the project a review of current work on Wynn Cassia in similar environments has been undertaken. A number of on-farm demonstration areas and monitoring sites have been established. Seasonal pasture growth, productivity and quality have been monitored on various commercial and research sites. Regular meetings have been held to discuss findings and changes to the program that may be required.

As part of this project the live weight gain of steers on a pure Wynn Cassia sward is being undertaken at DDRF to determine how well stock perform throughout the season. The findings of this aspect of the project appear under the project titled: Pasture Species Evaluation under Grazing at DDRF in this report

A feeding evaluation has been conducted at Berrimah Agricultural Research Centre to determine the performance of steers fed Wynn Cassia hay and pellets. Findings on these evaluations appear under the project: Evaluate the Use of Wynn Cassia as a Feed Source for Brahman Export Steer Rations in this report

The project will continue for another year and a final report will be published in 2003.

PROJECT: Evaluation of an Expert Management Program for Irrigated Peanuts

Project Officers: C. Ham, S. Lucas and F. O'Gara

Location: Douglas Daly Research Farm

Objective:

To evaluate the suitability of an expert management program for NT irrigated peanut production.

Background:

"Exnut", a United States Department of Agriculture (USDA) computer expert irrigated peanut management program, was evaluated during the 2001 dry season at Douglas Daly Research Farm. The objective of the Exnut program is to utilise soil temperature data, combined with irrigation and weather data to generate decisions on irrigation management. The aim is to improve economic returns and to reduce the risk associated with aflatoxin, foreign material, immaturity, off-flavours, chemical residue, and environmental impact. (Exnut users guide, USDA 1997).

Irrigated peanut production is a complex activity involving many variables. One major variable is the relationship between irrigation (frequency and quantity) and yield and grade. Most researchers agree that stresses at critical stages of growth are detrimental to yield. Some believe that stress carefully applied within defined periods of growth can enhance uniformity of flower-set and therefore improve grade and possibly yield. Exnut is designed to determine the length and intensity of these periods of stress using soil temperature information and rain and irrigation records. It makes decisions based on "if then" rules formed from a pooled knowledge base.

Exnut helps the user make irrigation decisions through a series of basic questions concerning weather, soil type, soil water, irrigation capacity, soil temperature, date, time since planting, and crop condition. Generally, the strategy schedules irrigation such that an optimum soil temperature is maintained in the pod zone. This helps control pests, achieve rapid emergence, promote good tap root and lateral root growth (Ketring and

Reid, 1993), prevent excessive vine growth, provide optimum conditions for fruit addition and maturation. It also provides optimum plant and soil conditions at harvest unless hampered by excessive rainfall. (Davidson, J. et al. 1995)

The 2001 demonstration was not replicated or compared to a control. This was not possible due to the limitations of the irrigation resource.

Monitoring tools

The paddock was monitored using Tinytag© data loggers to measure canopy temperature, humidity and soil temperature. Irrigation was measured using bore flow meters and the use of Enviroscan® soil moisture monitor. The Enviroscan has been field calibrated previously and set stress limits had been specified. Exnut dictated the application of all irrigations and all decisions were adhered to unless the moisture had declined to at or near permanent wilt point.

Results:

Machine harvested yield over 5.2 hectares was 2,155 kg/ha based on cleaned dry weight.

Birds caused significant damage to the trial throughout the pod fill/maturity stage. Brolgas have learned to shell peanuts over several seasons. The actual amount of damage is difficult to quantify as the damage occurs over a long period and is a gradual removal of maturing nuts. They are intelligent birds and very difficult to shift. Damage was estimated at 1.2 t/ha. The crop was harvested at 181 days after planting.

Conclusion:

During the initial phase of growth Exnut forced the plant root system to explore deeper profiles and to develop laterally and vertically in the initial phase, by imposing an irrigation deficit. The result of this was evident later in the season when plants did not show visible wilt in conditions which had imposed wilt in previous years. Observations indicate that flowering was initiated by the stress period rather than after the first large irrigation. This appeared to be more synchronous than previous years.

The program functioned well up until the point where soil temperatures dropped below 20°C. The logic within the program reduced water applications to try to raise soil temperature. There was an in-built rain probability setting within the program which also tended to decrease irrigations based on a “what if” chance of rain. In our climate the probability of rain during these cool periods is almost nil but the program assumed a 40% chance of rain at low temperatures. During this phase a general increase in pan evaporation and wind run occurred despite the cooler temperatures. This prompted the program to create a late season moisture stress. This was the most likely cause of low yield, over and above the bird damage.

Exnut provides very useful paddock records and a crop diary along with watering records and a soil temperature graph. However, Exnut is not practical to use in the NT in its current form unless some modifications are made. The modifications would address decision issues made during cool weather and allow for the lack of rain in our dry season. The USDA indicated that they would be interested in pursuing these issues in the future.

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SUBPROGRAM: Cotton Industry Development

PROJECT: Research of Dry Season Cotton Production

Project Officers: **C. Martin, A. Dougall, A. Ward, M. Kahl, S. Bellgard, R. Sunnerdale, M. Connolly, D. Summers, N. Shaw, R. Eastick, N. Hartley, C. Ham, S. Lucas and S. Yeates**

Location: Katherine Research Station

Objectives:

To develop an agronomic package for efficient and sustainable field production systems for cotton.

To identify the most appropriate varieties of cotton in terms of yield, quality and maturity.

To develop suitable irrigation systems for commercial scale cotton production.

Introduction:

Since 1993 DBIRD has been involved in a joint project with CSIRO and Agriculture WA to investigate the possibility of establishing a viable cotton industry in northern Australia. This work intensified with DPI becoming a core partner of the Australian Cotton CRC in 2000.

This project is based on the use of transgenic cotton grown in the dry season to minimise insect problems that contributed to the collapse of the Ord cotton industry in the 1970s.

The successful establishment of a cotton industry in the NT will depend on the availability of suitable land and irrigation water. It will also need the development of an integrated agronomy and entomology package for the successful production of the crop that will meet strict environmental guidelines.

Progress in 2001

About 15 ha of irrigated cotton was grown; 4.7 ha was irrigated with sub-surface drip irrigation (SDI) while the balance was irrigated with a lateral move over-head irrigator fitted with low energy precision applicators. About 13 ha of this area was planted with transgenic Ingard® cotton and the remaining 2 ha with conventional cotton sown as a refuge for resistance management purposes.

This was the second cotton crop in a "two in two out" rotation. Field summaries for the two seasons are shown in Table 1.

Table 1. Water use and cotton yield

	2000 Season			2001 Season		
Field	**Water Used (ML/ha)**	**Yield (bales/ha)**	**Insecticide Sprays**	**Water used (ML/ha)**	**Yield (bales/ha)**	**Insecticide sprays**
T1	5.46	6.5-9.5	2	5.23	8.83	6
T2	5.11		2	4.84	4.85*	5
B1	7.09		1	6.56	6.38	7
B2	5.85		-	6.28	4.85*	4
B3	5.52		-	5.48	4.85*	4

* The cotton from these three fields was bulked so actual yields are unavailable. Trial plots within these fields brought the overall average down.

Water use is minimal compared to surface irrigation in traditional cotton growing areas where around 8 ML are used depending on rainfall. Insect pressure, particularly from sucking pests was high in 2001 hence the larger number of sprays.

Experiments

Table 2. Two-year averages for the variety trial

Variety	Yield (bales/ha)	Yield as a % of 96480-71	Fibre length (inches)	Micronaire
96480-71	8.24	100%	1.11	4.01
Siokra V-16I	7.75	94%	1.08	3.83
Sicot 51I	7.69	93%	1.08	3.81
NuCotn37	7.69	93%	1.09	4.15
Sicala 40I	7.69	93%	1.08	3.88
Sicot 289I	7.51	91%	1.13	4.06
97421-152	7.34	89%	1.07	4.10
96459-42	7.23	88%	1.08	4.15
96456-185	7.06	86%	1.08	4.25
Siokra 201I	6.90	84%	1.07	3.93
Siokra S-101I	6.46	78%	1.05	3.88
Sicot 189	4.06	49%	1.12	3.85

At present fibre is discounted if below 1.09 inches in length. Micronaire is required to be between 3.5-4.9 to avoid a discount. Over two years 96480-71 has shown to be superior in yield and of acceptable fibre length, consequently a bulk area of 96480-71 has been planted in the 2002 season for further evaluation. Sicot 189 is the only non-Ingard® variety in the trial and consequently received severe insect damage reflected in its poor yield.

Irrigation:

We have established upper and lower soil water limits for cotton in the SDI and lateral move areas with an ENVIROscan® moisture probe. Gravimetric data is now required to link the ENVIROscan® values with actual soil moisture content.

Progress in 2002:

A 27ha centre pivot was installed over the wet season. Half the pivot is planted with Siokra V-16 and the other half with Sicot 289i. The purpose of this crop is to observe the insect dynamics in a larger and more meaningful area. The fields A1, A2, A3 and A4 have been planted to cotton after two seasons in a grass fallow. Modifications were made to the planter to allow application of a liquid basal fertiliser simultaneously with planting.

Agronomy trials in 2002 include a phosphorus nutrition trial, variety trial, disease studies, weed management trials, deep drainage studies and simulated insect damage trials.

PROJECT: Insect Dynamics of the Cotton Ecosystem in the Northern Territory

Project Officers: **A. Ward, K. Scrimp, D. Summers, N. Shaw and M. Connolly**

Location: Katherine Research Station

Objective:

To benchmark the ecology of the key pests and beneficial insects that are likely to impact on a future cotton industry in the Katherine area, before assessing preliminary integrated pest management systems.

More specifically the objectives of the project in 2001 were to:

1. Monitor key lepidopteran pests four weekly using pheromone traps at eight sites.

2. Assess resistance levels in *H. armigera* to conventional insecticides monthly during the season.

3. Determine the base-line susceptibilities of *H. armigera* and *H. punctigera* to BT.

4. Monitor *Trichogramma* activity and identify local species.

5. Make preliminary assessments of trap crops suitable for use in the Northern Territory.

6. Rear and identify beneficial insect species and rank their status in the NT and link data to biodiversity studies.

Progress in 2002:

Significant progress was made towards meeting the research objectives outlined above. The findings of this research are summarised below.

1. A pheromone trap network was established in April 2001 covering a total of eight sites. The sites include established agricultural areas, wet bush as well as dry bush environs. Sampling is continuing at weekly intervals at each site for the remainder of the project. Of the four species monitored, *Helicoverpa armigera* and *Spodoptera litura* were the most abundant. Virtually no *H. punctigera* and very few *Pectinophora gossypiella* were caught.

2. Resistance to conventional insecticides was assessed on three occasions throughout the 2001 cotton season. More frequent sampling was not possible due to delays in getting Helicoverpa diet material and the unavailability of eggs. The only data available suggests that there is 100% resistance to fenvalerate (RF = 30), 43% resistance to fenvalerate/pbo, 42% resistance to bifenthrin, 83% resistance to thiodicarb (13% homozygote), 11% resistance to spinosad and 14% resistance to profenofos. There was no resistance recorded to chlorpyrifos.

3. The bioassays to determine the baseline susceptibility of local *H. armigera* to BT have been successfully completed. No larvae survived when exposed to Dipel and Xentari at 2mg/mL. Survival of grubs exposed to MVP at 3 µL/mL was 11.6 %. This result is similar to that obtained in Kununurra with a survival of 12.1%.

4. Trichogramma parasitism levels were assessed on five occasions between April and July after which it was difficult to collect eggs. Efforts to identify the species responsible for the parasitism observed were unsuccessful due to problems with the method of obtaining, collecting and preserving samples. When the appropriate method became available, parasitism levels had dropped to zero. Trichogramma wasps have since been collected and forwarded to Andrew Davies for identification.

5. Six crops (Lab lab, niger, pigeon pea, kenaf, chickpea and sesame) were screened as potential trap crops for use with cotton in the NT. Chickpea and sesame were ruled out due to attack by wallabies and insects. The relative attractiveness of the remaining crops to a range of pests and beneficial insects are summarised in Table 1

Table 1. Ranking of trap crops tested at Katherine for their attractiveness to a range of pest and beneficial insects. Crops labelled 1 are the most attractive and 5 are the least attractive.

Crop	*H. armigera* larvae	GVB	RBSB	Brown mirid	Total pests	Beneficials	Total all insects
Lab Lab	1	1	1	1	4	3	7
Pigeon Pea	4	2	2	2	10	5	15
Niger	2	5	3	1	11	2	13
Kenaf	5	3	5	3	16	1	17
Cotton	3	4	4	5	16	4	20

6. Regular sampling to determine the spectrum of pest and beneficial insects present in cotton and trap crops at Katherine was undertaken throughout the cotton season using Devacs and visual techniques. A range of beneficial insects has been identified including spiders, predatory bugs and beetles. Tricogramma, microplitis and tachinids have also been reared from eggs and larvae collected from the cotton grown at Katherine. Additional sampling has been undertaken in the broader environment to determine potential sources of beneficial and pest insects.

Future directions

In 2002 the following work is proposed:

- Continue to monitor key lepidopteran pests four-weekly using pheromone traps at eight sites.
- Continue resistance testing and develop a resistance management strategy for *H. armigera* and *Aphis gossypii.*
- Monitor for BT resistance.
- Continue to assess the suitability of various trap crops for use in the NT.
- Assess the impact of sucking insects on cotton grown in the NT.
- If not present, introduce *Trichogramma pretiosum* from Kununurra.
- Rear and identify beneficial insect species and rank their status in the NT.

SUBPROGRAM: Weeds Management

PROJECT: Broadleaf Weed Control in Grass Pastures

Project Officers: **R. Eastick, N. Hartley, P. Hausler, B. Beumer and C. Martin**

Location: DDRF, Mt. Keppler, Carmour Plains

Objective:

To evaluate a range of herbicides for control of broadleaf weeds in grass pastures.

Background:

Pastoralists expressed concerns about the lack information on broadleaf weed control in perennial grass pastures. They wanted to know how to rehabilitate established grass pastures which had declined in productivity due to invasion of weeds and establish improved pastures with grass species such as Jarra (*Digitaria milanjiana*), Sabi (*Urochloa mosambicensis*) and Buffel (*Cenchrus ciliaris*). A grass only pasture allows a phase for broadleaf weed control through selective herbicide application. This may assist in reducing future weed burdens in following crops, such as cavalcade, and maintain the productivity of the pasture for grazing.

There were a number of herbicides and herbicide combinations being used for broadleaf weed control in grass pastures. We aimed to compare some of these herbicides for efficacy and cost effectiveness against weeds.

Method:

Herbicide demonstration plots were established at three sites:

1. Tippera block on Ruby Downs. Sabi grass based pasture was declining in productivity. The major weeds were also present. The paddock had been slashed a month before herbicide application, with subsequent good growth of weeds, providing an adequate leaf area and plant height for spraying.

2. Mt. Keppler in the Adelaide River region. Newly established *Digitaria swynerrtonii cv.*Arnhem. The major weeds were annual Digitaria species, Senna (*Senna obtusifolia*), Sida (*Sida acuta*), Hyptis (*Hyptis suaveolens*) and *Corchorus* spp.

3. Carmour Plains in the Marrakai region. Dominated by *Sida* spp and *Senna obtusifolia.* No improved grass species were present.

Herbicide application:

- Herbicides were applied at the three sites between 12 and 20 March, with a 3 m boom mounted on the back of a quad bike.

- Tank mix was applied at 100 L/ha

- Herbicide strips were 50 m long and 6 m wide.

- The herbicide strips were assessed for damage to the Sabi (Ruby Tippera site) and Arnhem (Mt. Keppler site) and each of the weed species at 3 weeks after spraying. Damage was rated from 0: no kill to 10: complete kill.

The applied herbicide treatments were:

1. Brushoff® (40 g/ha) + Chemwett (0.2%)
2. Brushoff® (20 g/ha) + 2,4-D amicide 625 (1.6 L/ha) + Chemwett (0.2%)
3. Diuron 500 (2 L/ha) + 2,4-D amicide 625 (1.6 L/ha) + Chemwett (0.2%)
4. Nutrazine® (4 L/ha) + 2,4-D amicide 625 (1.6 L/ha) + Chemwett (0.2%)
5. Starane® (1.5 L/ha) + 2,4-D amicide 625 (1.6 L/ha) + Chemwett (0.2%)
6. Grazon® (300 mL/ha) + 2,4-D amicide 625 (1.6 L/ha) + Chemwett (0.2%)
7. Tordon75-D® (1 L/ha) + Chemwett (0.2%)

Results:

- There was no visible damage to the Arnhem at the Mt. Keppler site. It was difficult to draw conclusions about weed damage for this site because the mature weeds browned off soon after the application of the herbicide, as there was very little follow-up rain. However, trends for herbicide efficacy did appear similar to those from the Ruby Tippera site.

- At the Ruby Tippera site, no herbicide damaged the Sabi. In all the strips except the Diuron and Atrazine plots, the Sida was still surviving and producing green shoots. The Hyptis was totally killed in all plots (damage ranking: 10), except the Tordon 75D plot which had the isolated surviving Hyptis plant (damage ranking: 9).

- No results are presented for the Carmour Plains site because of technical difficulties at the time of spraying.

Table 1. Approximate cost (excluding GST) for each of the herbicide treatments

Trade Name	**Active ingredient**	**Rate (product/ha)**	**Cost ($/unit herbicide)**	**Cost ($/ha of product)**	**Weed kill ranking (0: no effect 10: total kill)**
Tordon 75-D	Picloram(75 g/L)	1 L/ha	$45/L	**$45**	Senna: 9 Sida: 2 Pennisetum: 0
Grazon DS and 2,4-D amicide	Triclopyr(300 g/L) Picloram(100 g/L) 2,4-Damicide (625 g/L)	300 mL/ha 1.6 L/ha	$56/L 7.30/L	($16.80+ $11.70)= **$28.50**	Senna: 8 Sida: 2 Pennisetum: 0
Starane and 2,4-D amicide	Fluoroxypyr (200g/L) 2,4-D amicide (625g/L)	1.5 L/ha 1.6 L/ha	$25/L $7.30/L	($37.50+ $11.70)= **$49.20**	Senna: 7 Sida: 5 Pennisetum: 0
Nutrazine and 2,4-D amicide	atrazine (500 g/L) 2,4-D amicide (625 g/L)	4 L/ha 1.6 L/ha	$6.15/L $7.30/L	($24.60+ $11.70)= **$36.30**	Senna: 9 Sida: 9.5 Pennisetum: 2
Diuron (flow') and 2,4-D amicide	Diuron (500 g/L) 2,4-D amicide (625 g/L)	2 L/ha 1.6 L/ha	$8.50/L $7.30/L	($17.00+ $11.70)= **$28.70**	Senna: 9.5 Sida: 9.5 Pennisetum: 9
Brush-off and 2,4-D amicide	Metsulfuron (600g/kg) 2,4-D amicide (625 g/L)	20 g/ha 1.6 L/ha	$0.35/g $7.30/L	($7.00+ $11.70)= **$18.70**	Senna: 8 Sida: 4 Pennisetum: 3
Brush-off	Metsulfuron (600 g/kg)	40 g/ha	$0.35/g	**$14.00**	Senna: 7 Sida: 5 Pennisetum: 5
Surfactant	Chemwett	0.2% (80 mL)	$13.10/L	**$1.00**	

A plant damage rating is included for the three major weeds present in the paddock at time of spraying for the Ruby Tippera site.

Discussion:

1. *Weed Growth Stage*: Ideally, application should occur early in the season (November-December) after weeds have emerged, and prior to seed set, to allow subsequent competitive pasture growth over the wet season. However, weed control later in the wet season is also practised, by which time seed set has occurred. Is it worthwhile spraying at this time? It is proposed that a future targeted experiment would

address this question. This would involve herbicide application at two times (early and late in season), measurements of relative pasture growth, and relative weed regeneration in the next season.

2. *Seed Viability*: If weeds with seed set are sprayed, does this affect seed germinability, and thus reduce amount of weeds present the next season? Seeds were collected from Senna and Pennisetum to conduct germination tests. Results are being collated, but there appeared to be a reduction in viable seed.

3. *Desirable Species Tolerance*: Need to consider differences in herbicide tolerance of the desirable species. For example, buffel and Guinea grass may be damaged to unacceptable levels by Diuron, although there may be differences in damage with rate differences. This may provide an avenue for annual grass control (particularly *P.pedicellatum*) in perennial grass species.

4. *Palatability of Desirable Species*: Different grass species will be subject to different grazing pressure (e.g. Jarra compared with Signal grass). Perhaps a slight decrease in cattle weight gains from grazing less palatable species would be balanced by less invasion of weeds from fewer bare soil patches, and thus decreased herbicide requirement (and cost)?

5. *Growth of Desirable Species*: There was very little rain on this area after the herbicides were applied. This affected the growth of the sabi and its opportunity to ‘take off’ and compete with the weeds when they were damaged by the herbicide.

6. *Ease of Chemical Use*: Some herbicides may be easier to apply/ be compatible than other mixes. For example, Diuron may clog nozzles.

7. *Crop Rotation:* Need to consider the following crop or pasture rotation (in conjunction with soil type) as some herbicides (e.g. Picloram) have considerable residual activity (may also be different between seasons depending on rainfall).

8. *Efficacy:* In considering efficacy, also consider whether the herbicide is providing any residual control of newly germinating seedlings (e.g. Diuron), or whether second applications may be required (e.g. Starane).

9. *Rates:* There is the potential to manipulate rates to lower levels, particularly of the herbicides which were the most effective e.g. atrazine and Diuron, and also the level of the 2,4D amine used in the mix.

10. *Herbicide Resistance*: Herbicides are grouped according to their mode of action (how they interfere with processes in the plant to cause damage). If weeds are treated repeatedly with herbicides from the same group, they may develop resistance, with the establishment of a dominant weed population on which that group of herbicides will no longer work. There is a need for alternative options for continuous pastures and crop pasture rotations.

Conclusion:

- The Diuron/2,4-D mix provided the best weed control overall, followed by the atrazine mix then the Brushoff mix.

- Considering cost effectiveness, the Brushoff mix is probably the best, although it may be worth spending a little more for a more effective overall kill? Weed dynamics and economic thresholds are still not clear for northern agricultural systems.

- Early season application may lead to a reduction in rates and thus, cost for some herbicides.

- Chemical control is only one component of weed management. Other options such as crop/pasture rotation, use of competitive grass pastures, and particularly, grazing management, need also to be considered.

PROJECT: Weed Management in Cotton Production Systems

Project Officers: **A. Dougall, R. Eastick, N. Hartley and M. Kahl**

Location: Katherine Research Station, Berrimah Farm

Objective:

To evaluate a range of herbicides for control of weeds in a cotton production system.

Background:

The formulation of weed management strategies appropriate for sustainable cotton production in the Top End of the NT is a continuing research priority. A sustainable farming system would likely include crops grown in rotation with cotton. Potential crops would be cavalcade or peanuts, which could subsequently end up as weeds in a cotton crop. Stomp® (pendimethalin) applied pre-emergent (4 L/ha) and Verdict® (haloxyfop) forms the basis of current chemical weed control, and was considered as the best-bet strategy. Staple® (pyrithiobac) is an option for post-emergent control. The advent of new chemical formulations requires assessment of these chemicals under northern irrigated cropping systems. We aimed to compare an existing over-the-top herbicide, Staple® with a recently developed herbicide, tryoxysulfuron (TS) for efficacy against weeds, and phytotoxicity of cotton.

Method:

There were two components to this experiment:

- Part A: Application of herbicides in a field experiment within the cotton production area.
- Part B: Application of herbicides to specific weeds sown in a pot trial.

Part A
The trial was conducted under the lateral move irrigator at Katherine Research Station using a randomised complete block design. Siokra V-16i was sown on the 15 April, and the herbicides were applied four weeks later with the Agmurf ® experimental sprayer, when the cotton crop was 30 cm high (4-8 leaves). Plots consisted of six rows, each 15 m long.

Herbicide treatments were:

1. Best bet/traditional management plus 120 g Staple® “over-the-top” spray (100% band).
2. Best bet/traditional management plus 15 g TS “over-the-top” spray (100% band).
3. Best bet/traditional management plus 30 g TS directed spray (80% band).
4. Stomp only.
5. No herbicides and hand weeded (crop only).
6. No herbicides and not hand weeded (crop + weed).

Crop phytotoxicity, weed damage rating and photographs were taken two weeks after the application of herbicide treatments. Verdict® was also applied at this time to all plots except the crop only and crop + weed plots.

Crop phytotoxicity, weed damage rating and photographs were taken near canopy closure 11 weeks after sowing. Weed biomass (1*1m quadrat) and cotton biomass (2*1 m of row) were also assessed at this time.

Weed biomass will be measured immediately prior to defoliation of the cotton crop before harvest, which is predicted to be at the end of October. Final cotton yield will be determined by hand-harvest of 2*1 m of row, then a 2*10 m by machine harvest.

Results:

The experiment is due to be harvested in Oct-Nov 2002. Final results will be presented after this time.

Part B

This component supplements the cotton herbicide field experiment conducted at Katherine. The patchiness of weeds in the field required that efficacy of the herbicides on specific weeds be assessed. Sowing a range of weed seeds in a pot trial aimed to do this.

Method:

A pot trial was conducted at Berrimah Research Farm using a randomised complete block design. Seed was sown on 5 June and herbicides were applied seven weeks later with the Agmurf ® experimental sprayer. Cotton was included to assess damage, and to indicate growth stage when herbicide application would be appropriate.

Herbicide treatments were:

1. 120 g Staple® “over-the-top”
2. 15 g TS “over-the-top”
3. 30 g TS ‘over-the-top’
4. Control (no herbicides)

Weed treatments were:

1. *Senna obtusifolia* (Senna)
2. *Macroptilium lathyroides* (Phasey bean)
3. *Alysicarpus vaginalis* (Buffalo clover)
4. *Crotalaria goriensis* (Crotalaria) #
5. *Hyptis suaveolens* (Hyptis)
6. *Lablab purpureus* (Lablab)
7. *Centrosema pascuorum* cv. Cavalcade
8. *Gossypium hirsutum* (Cotton)
9. *Arachis hypogaea* (Peanuts)

#Crotalaria did not emerge, so was replaced with Tridax Daisy (*Tridax procumbens)*

Crop phytotoxicity, weed damage rating and photographs were taken one and four weeks after herbicide treatments were applied.

Results:

Final results will be presented in conjunction with the cotton herbicide field component after harvest.

PROJECT: Evaluate Wynn Cassia as a Feed for Brahman Export Steers

Project Officers: **G. Schultz, N. Hartley, B. Lemcke and P. Caley**

Location: Berrimah Farm

Objective:

To determine the feeding value of Wynn cassia hay and pellets for penned steers in comparison with Cavalcade and pangola hay.

Background:

Producers in the Douglas Daly area expressed concern about the suitability of *Chamaecrista rotundifolia* (Round-leafed cassia, Wynn) hay as a source of feed for cattle. As there was no clear information on this issue, Douglas Daly producers started a Producer Initiated Research and Development Project (PIRD) in 2001. As a part of this project, Wynn hay was compared with Cavalcade *(Centrosema pascuorum*) hay, pangola (*Digitaria eriantha*) hay and pellets of Tully *(Brachiaria humidicolia)* mixed with cottonseed, by feeding steers in pens at Berrimah Farm. One of the main problems reported with Wynn is the loss of leaf in the drying process to make hay. Its low palatability cannot be explained by any apparent nutrient deficiencies. Low palatability is common in legumes, but Wynn cassia can suppress weeds and grasses if the paddock is grazed heavily. It also appears that there may be a phase-in period for stock accepting Wynn cassia as a feed. There may also be a need for phosphorus fertiliser on a regular basis to increase acceptance.

Method:

Trial 1

Wynn, pangola and Cavalcade hay was fed to three steers in a pen replicated twice. Tully/cotton pellets were fed to three steers in a single pen. The animals were weighed weekly, un-fasted, fat measurements were taken, and *ad lib* feed intake was measured on a daily basis. Round bales of Wynn were supplied by Theyona Station, Cavalcade by the Douglas Daly Research Farm (DDRF), pangola hay by Berrimah Farm and Tully/cotton pellets by the feed mill of Australasian Farms Pty Ltd. The pellets were a combination of Tully and fuzzy cotton, molasses and cooking oil. Molasses and recycled cooking oils are necessary ingredients to manufacture pellets. Yearling Brahman-cross steers were from DDRF. A mineral block (Phosrite®) was supplied to each pen.

Results:

Table 1. Performance of steers fed Wynn, Cavalcade and pangola hays compared with Tully/fuzzy cotton pellets

Feed	Crude protein (%)	Average weight (kg) Day 1	Average weight (kg) Day 9	Average weight (kg) Day 36	Fat depth change-P8 (mm)	Phosrite® (g/head/day)	Feed intake (kg/day)
Wynn	6.5	319	306	297	-2.5	66	3.08
Cavalcade	9.06	315	316	318	-1.1	75	4.23
Pangola	3.13	316	314	319	-1.5	61	4.99
Tully/cotton pellets	6.88	315	310	334*	0	90	7.96

* Weight after 32 days when supply ran out.

Discussion:

Only steers fed Cavalcade did not lose weight in the first week. Animals fed Wynn cassia lost the largest amount of weight, averaging a loss of 21 kg in 36 days. The animals fed pellets had a significantly better weight gain (0.59 kg/day) over the hay feeds with Wynn hay having a statistically significant loss over the other feeds (-0.61 kg/day). Feed intake/weight gain ratio was positive for pangola, Cavalcade and pellets and negative for Wynn cassia hay. All hay-fed animals had a reduction in fat depth over the period of the trial while the pellet-fed animals maintained their condition. It was observed that the animals on Wynn cassia actively ate the leaf and rejected much of the stalky stem material. Their intakes were far too low to expect them to maintain weight.

Trial 2
Wynn cassia pellets were compared with pangola hay when fed to lighter yearling Brahman-cross steers. The pellets were formulated by the addition of 21% grain sorghum, 5.8% cooking oil and 3.1% molasses. Measurements were the same as in trial 1.

Results:

Table 2. Performance of steers fed Wynn cassia pellets compared with pangola hay

Feed	**Crude protein (%)**	**Average weight (kg) Day 1**	**Average weight (kg) Day 9**	**Average weight (kg) Day 25**	**Fat score (mm)**	**Phosrite® (g/day)**	**Feed intake (kg/day)**
Wynn pellets	7.5	275	281	292	0.8	85	6.37
Pangola hay	4	276	268	277	-1	75	4.05

The feeding of supplemented Wynn pellets gave a significantly improved response over pangola hay. In the 25 days the pangola-fed animals regained lost body weight while the Wynn-fed animals gained an average of 17 kg. This is reflected in their daily feed intake of 6.37 kg over 4.05 kg for the pangola–fed animals. When compared with the results in Trial 1, animals fed both Wynn and Tully/cotton based pellets, performed better than those fed Wynn, Cavalcade or pangola hays. None of the hays would be considered as high quality feed; they were only of average standard. When protein values are considered, animals on pangola hay performed remarkably well. Wynn cassia pellets without the sorghum grain would have given a better understanding of the nutrient quality of Wynn cassia apart from the palatability problem of the hay.

SUBPROGRAM: Agroforestry

PROJECT: Agroforestry

Project Officers: **D. Reilly, B. Robertson, K. Neitzel and M. Clark**

Location: Four sub-regions of the Top End: Lower Mary River, Katherine, the Daly region and the Darwin Rural area on private properties.

Objectives:

To encourage the incorporation of farm forestry on cleared agricultural land in the Top End region.

To promote wood and non-wood production and to integrate it with other farming activities.

Method:

The Top End Regional Tropical Hardwood Forestry project, which is funded by the Natural Heritage Trust, has completed a three-year planting program. The project began in 1998 with the establishment of eight trial sites in the four identified sub-regions of the Top End. This was followed in the next two years by the planting of another 16 sites, which brings the total to 24 sites across the Top End of the NT. Each trial site is 1 to 2 hectares in size. These sites will also help form the focus of on-going research and development and be the basis for extension, education and training. The plants on preliminary trial sites have been measured and assessed for growth and performance across the four main agricultural sub-regions of the Top End.

The selection of suitable species and provenances of trees for planting out on to private properties was undertaken by a steering committee, which chose an appropriate mix of exotic and native hardwoods. The main selection criterion for the species was that they be high-value hardwoods, irrespective of origin, native or introduced. Efforts were made to include as many native species as possible without compromising the objective of the project.

In the first year, a total of 12 species were selected for the research trials and/or demonstration plots across all the selected sites. These included:

African mahogany (*Khaya senegalensis*);
Two species of American mahoganies (*Swietenia humilis* and *S. macrophylla*);
Rosewoods (*Pterocarpus* spp),
West Indian Cedar (*Cedrela odorata*);
Teak (*Tectona grandis*);
Talisan (*Terminalia belerica*);
Indian mahogany (*Chukrasia velutina*).
Australian natives included:
Red Mahogany (*Eucalyptus pellita*);
Red Cedar (*Toona ciliata*; and
Black Bean (*Castanospermum australe.*

Over the next two years of planting, these made up the core species for evaluation with additions made according to soil types and land-owner wishes. Additional tree species planted in subsequent years included Cypress Pine, Leichardt Pine, Paperbarks, Ironwood, Bush Apple and the Central American tree species, *Enterolobium cyclocarpum.*

All trials were laid out in a randomised complete block design. On each site six species were to be planted, each represented by 7 x 7 plant plots in four replications (= 196 plants per species). Preparation of the sites as well as fencing and maintenance of the trial area including weed control was the responsibility of landowners. In most cases the seedlings were planted into already cultivated lines (not always possible) at a spacing of 3 m between rows and 3 m along rows, resulting in a stocking rate of 1,111 stems per hectare.

Most seedlings were raised either in “Plantek Side Slot Trays” or “Hiko” 40 cell trays using a potting mix of sand, coco peat, perlite and osmocote. Seed was sown in August/September and trays were placed in shade houses. Seedlings for some species were obtained from the Howard Springs forest reserve where re-generation from former evaluations has yielded large numbers of seedlings. These were pulled from the ground and propagated in small pots or planted directly into the new trial areas. Species obtained as striplings in this manner were African mahogany, Rosewood, Indian mahogany and Terminalia belerica.

Results:

Measurements were first taken six months after planting which was in December/January and then on an annual basis after that. We are at the stage now where we have data from three different age classes of trees, over a number of sites (soil types) and from two different climatic conditions, Katherine and Darwin. Data was collected in June and July 2002 when trees were measured for height and where appropriate, diameter of the trunk was measured when trees were 1.3 m high - diameter at breast height (DBH).

The Figures below indicate the best performing species across a number of sites and include African mahogany, Teak, American mahogany and *Eucalyptus pellita*.

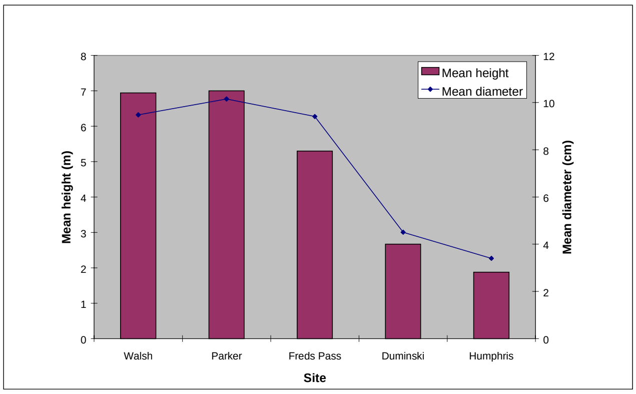

Figure 1. Mean height and diameter of African mahogany at 42 months across a number of sites

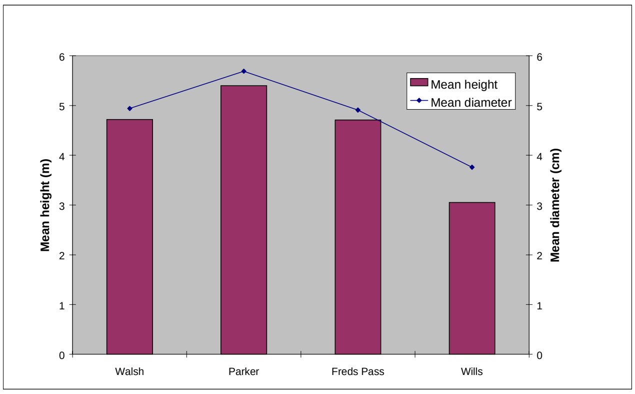

Figure 2. Mean height and diameter of Teak at 42 months across a number of sites

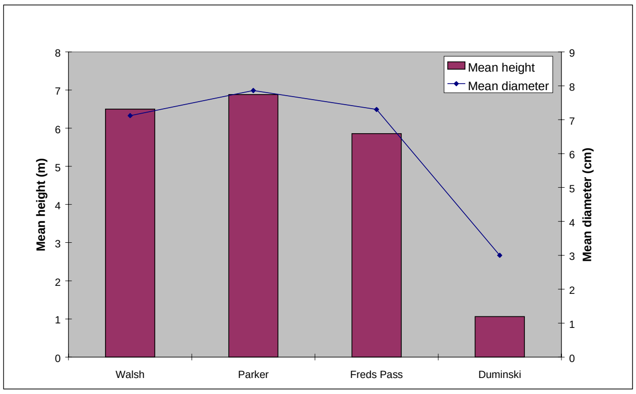

Figure 3. Mean height and diameter of American mahogany at 42 months across a number of sites

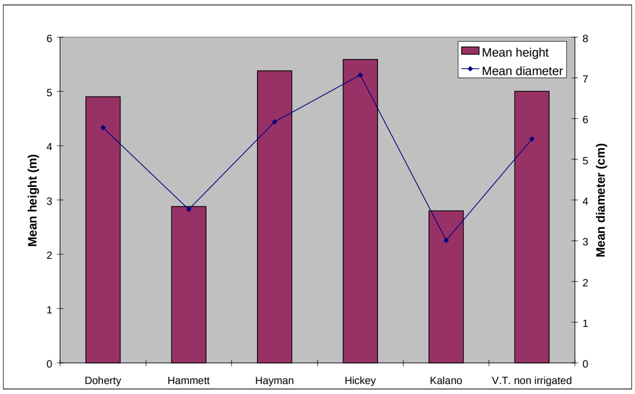

Figure 4. Mean height and diameter of *Eucalyptus pellita* at 30 months across a number of sites

Overall the best performing species at 42 months were African mahogany that is averaging nearly 7.0 m in height on two properties in Katherine and American mahogany that is just under 7.0 m in height on the same two properties. The important difference between the two species is in trunk diameter, which is 9.48 cm and 10.15 cm for African mahogany and 7.12 cm and 7.86 cm for the American mahogany, both on the same two Katherine properties. The differences between sites indicate the requirement for relatively fertile and well-drained soils for high value hardwoods in the NT environment. The "Duminski" and Humphris" sites were both characterised by heavy compacted soils, both of which became quite water-logged during the wet season.

The variation for the growth of E. pellita in Figure 4 was not due to soil type variations but more a consequence of poor management and lack of maintenance where fire and weeds influenced tree growth and survival. Some other species that are showing promise across some sites (but have not been as widely planted as those above) include the Rosewood, *Pterocarpus indicus* and where irrigation is available, the big leafed mahogany, *Swietenia macrophylla,* both of which are doing well. These latter species of trees tend to suffer from apparent moisture stress when the irrigation has been cut back or turned off. This characteristic appears to be true of many of the species chosen that originate from regions of high rainfall, which include Australian Red Cedar, *Toona ciliata* and the Blue Quandong, *Elaeocarpus grandis.*

PROJECT:	**Species Testing and Genetic Improvement of Forest Trees for the Northern Territory (RIRDC/LWRRDC/ FWPRDC) Joint Venture Agroforestry Program**
Project Officers:	**D. Reilly, B Robertson, with Dr G. Nikles and K. Robson of the Queensland Forestry Research Institute (QFRI)**
Location:	Top End of the NT and two sites in Northern Queensland.

Objectives:

Develop a farm forestry industry in the Northern Territory by providing information on the adaptability and potential growth rates of existing high quality native and exotic genotypes on a range of sites in the region.

Develop genetic facilities suitable for seed production and selection of superior plants for further breeding work.

Maintain acacia and eucalypt genetic facilities of QFRI in North Queensland.

Improve the expertise of DBIRD staff in genetics and tree breeding.

The methodology for this project should be based on a staged approach for the rapid development of high yielding forest tree varieties. These stages include:

- Parallel testing of 'best bet' taxa (species, provenances and hybrids).
- Development of commercial varieties matched to sites, from the superior taxa identified in trials.
- Infusion of new genetic material including various locally produced hybrids.
- On-going breeding for refinement of superior varieties.

The approach also incorporates best practices in all aspects of the project, and maximises the publicity and effective 'take up' of the results.

Method:

Trees were planted for a taxa trial in the Darwin River region and a seedling seed orchard at Howard Springs during the 2000/01 wet season. The 1.7 hectares area at Darwin River was planted with 32 different species, provenances, hybrids and clones of hardwood trees for evaluation in the NT environment (see Table 1 for species composition). At Howard Springs, the Eucalyptus pellita seedling seed orchard was established on a 3-hectare site comprising four provenances planted in a randomised complete block design replicated across the site. As the number of families varied between each of the provenances, it was decided to plant two rows of each of the Kiriwo and Goe (PNG) provenances per block and one row of each of the Melville Island and Serisa (PNG) provenances per block. The large number of families in the Kiriwo and Goe provenances is shown below.

- A bulk lot of 30 selected from a Melville Island provenance trial (seed lot 19718).
- A Kiriwo provenance from PNG (seed lot 19206) – 71 families.
- A Goe provenance from PNG (seed lot 19207) – 59 families.
- A Serisa provenance from PNG (seed lot 18199) – 12 families and a Serisa provenance from PNG (seed lot 18955) – 24 families. These two provenances were bulked together.

Seedlings were planted in 16 rows with six rows per block and a total of 36 blocks. The spacing was 4 m between rows and 2 m along the rows, resulting in a stocking rate of 1,250 stems per hectare. After planting, 50 kg/ha of phosphorus was applied in a circle around each seedling at both sites. At both the taxa and the seedling seed orchard trials, preparation consisted of deep ripping and mounding rows, and a pre-plant application of glyphosate along the rows at 1-2 L/ha. A post plant spray of Simazine along the rows at 6 L/ha for residual weed control was applied after planting only along the rows approximately one metre wide. Slashing the inter rows has been maintained at both sites to reduce weed growth. Hand spraying with glyphosate was necessary at both sites to reduce initial weed competition on the seedlings as the Simazine had minimal effect at the rate applied, especially on the heavier clay site.

Table 1. Species and provenance composition in the Taxa trial at the Darwin River property

Species	Provenance	Seed lot No./Source	Experiment
Eucalyptus pellita	Melville Is, Serisa (PNG) and Qld SSO	19718, 18199/18955 and 5203	Taxa trial
Acacia crassicarpa	Oriomo (PNG) and Fiji SO	19731 and 20003	Taxa trial
Acacia mangium	Qld SO	10204	Taxa trial
Eucalyptus camaldulensis	Katherine and Thai SO	10537 and 20383	Taxa trial
Eucalyptus cloeziana	Herberton and Koorboora	137 and 10682	Taxa trial
Corymbia citriodora	Hughenden and Glenden	11148 and 10895	Taxa trial
Eucalyptus tetradonta	Darwin collection	Local Darwin region	Taxa trial
Corymbia nesophila	Cape York Qld	North Queensland	Taxa trial
Eucalypt hybrid clones	*E. camaldulensis* x *E. grandis* (C x G)	Kleinig collection clones No. 9,10,11 12,13 and 20	Taxa trial
Eucalypt hybrids seedlings	*E. urophylla* x *E. pellita* and *E. urophylla* x *E. grandis*	M1677 x lep6-034, M1677 x lep7-015, 012 U X G (B5993) and (B10509)	Taxa trial
Khaya senegalensis	Darwin collection		Taxa trial
Khaya anthotheca	Darwin collection		Taxa trial
Pterocarpus dalbergioides and P. macrocarpus	Darwin Collection		Taxa trial
Chukrasia tabularis	Thanh Hoa Vietnam	20035	Taxa trial
Swietenia humilis	Central America		Taxa trial

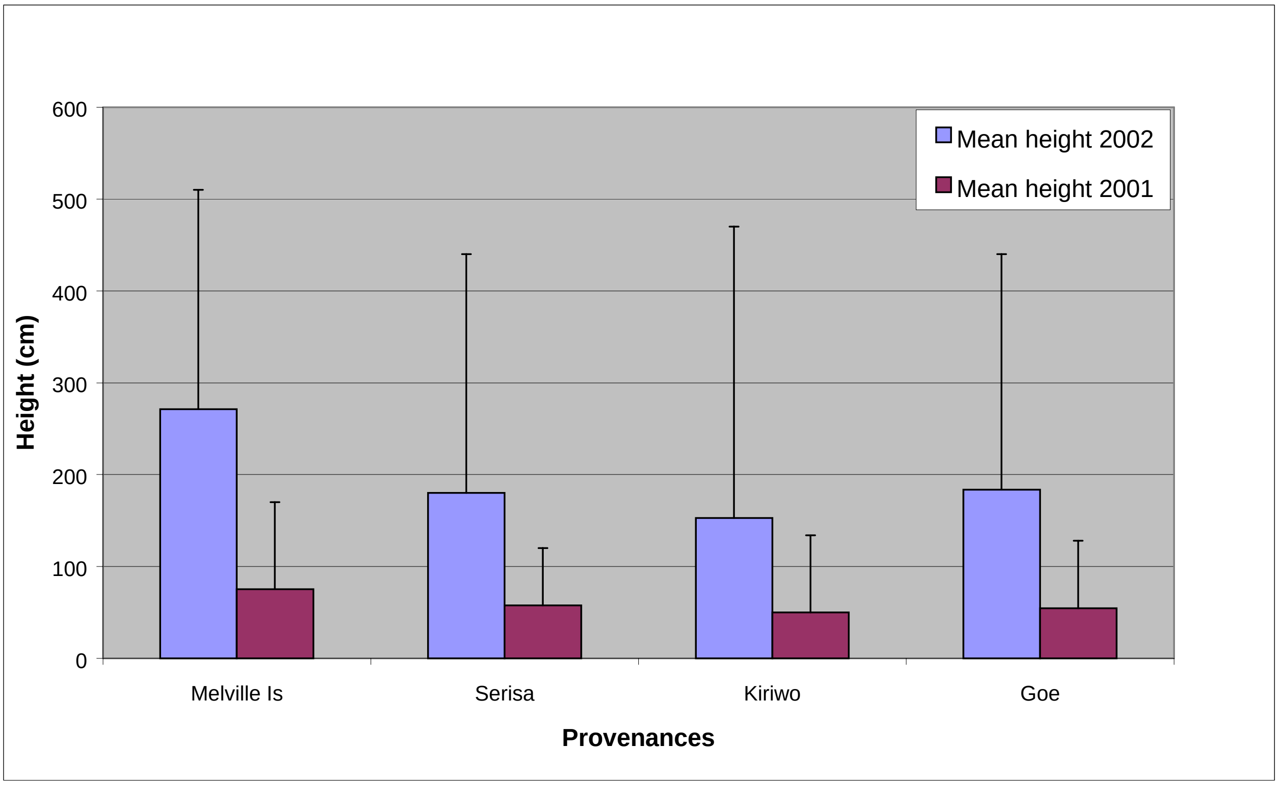

Figure 1. Mean height of *E. pellita* provenances at Howard Springs at four and 15 months

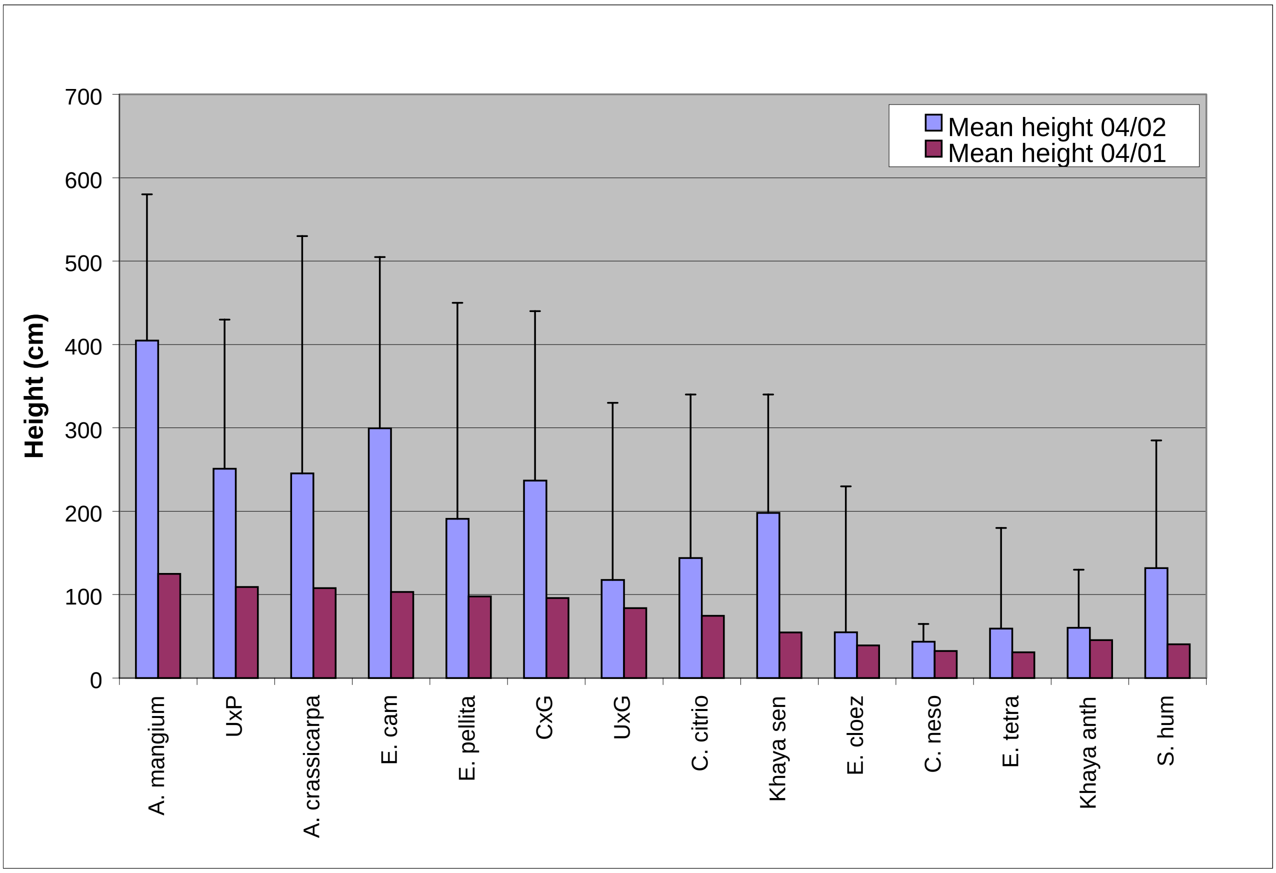

Figure 2. Mean height of species in NT taxa trial at the age of four and 16 months. Error bars indicate maximum heights.

In the second year of the project, it was decided that the African mahogany, *Khaya senegalensis* warranted further work to improve the form of the species and to conserve the genetic resource of a series of provenance trials at Gunn Point. Uncertainty exists as to the future of these valuable plantings at Gunn Point site due to wild fires, land tenure changes and development proposals in the area. The increasing interest in developing commercial plantations of this species from commercial entities across the north of Australia has also prompted DBIRD Forestry Section to establish a gene conservation orchard or clonal seed orchard on a safer site, closer to Darwin.

The Forest Research Institute, later known as the CSIRO first planted dry zone mahogany (*Khaya senegalensis)* in Darwin in 1959. Early growth figures were good and large trees, some over one metre in diameter still exist in and around Darwin. CSIRO could see the potential of *Khaya* in the Top End as a plantation species and in the 1970/71 wet season started to establish provenance trials at Gunn Point. These trials were established over three consecutive years, representing 20 different provenances within the trials. The Gunn Point trials have never been thinned although the stocking rate has been reduced a little, as some of the better trees have been utilised for timber by the Prison Farm established in the area. However, these provenance trials are probably one of the broadest based extant collections of the species – certainly in Australia, if not the world and therefore the genetic resource needs to be conserved.

Khaya senegalensis or dry zone mahogany from the Meliaceae family is a large semi-deciduous tree to 35 m in height and over 1 m in diameter. The timber is considered to be of very high quality and its uses include furniture making, plywood, counter tops, joinery, turnery and carving. In Africa it occurs in riverine forests and higher rainfall savannah woodlands. Its distribution is from Senegal on the west coast, to Sudan and Uganda on the eastern side of the continent. Khaya is adaptable to a wide range of soil types and will tolerate seasonal water logging. During the first year of growth, the tree develops a strong, deep taproot, which makes it the most drought-hardy of all the Khaya species; hence the common name, “dry zone mahogany”.

To satisfy the needs of a number of prospective growers interested in planting and developing plantations of the species, we should be in a position to provide them with good genetic material. During 2001, DBIRD Forestry Section staff selected superior candidate trees on the Gunn Point site. Each selected tree has been allocated a number and coordinates and measurements recorded. Scion material was collected from these superior trees and grafted onto rootstock, (previously collected as striplings and grown in the nursery). Several different graft unions were tried and the only one that proved successful initially was the side cleft graft. The failures proved to be more a result of the low humidity levels rather than the techniques used in grafting. This was borne out once the humidity began to rise, as more and more grafts were successful, when a number of different grafting techniques were used. Enough grafted clones were produced off a range of selected trees within each provenance to establish a 384 tree clonal seed orchard at Howard Springs and a 192 tree clonal seed bank at Berrimah Farm. There is currently limited knowledge of the breeding system of Khaya and it is unknown whether the species is self-incompatible or whether it is capable of ‘selfing’. These unknowns made it difficult to design the orchard and as a result, it is planted in a non-blocked, permuted neighbourhood design with four representatives of each provenance planted in the clonal seed orchard and two of each in the clonal seed bank at Berrimah. During the following year, very few clones had to be replaced due to death. Where plants died, they have been replaced with the same clone number or if not available, another clone from the same provenance to maintain the integrity of the seed breeding orchard.

Table 2. Provenances of *Khaya senegalensis* represented by year of planting at Gunn Point (superior selected trees in brackets)

Seed code	Provenance	1970/71 (EP 363b)	1971/72 (EP388)	1972/73 (EP420)
D391	Central African Republic	+ (7)	+ (1)	-
D407	Uganda	+ (5)	-	-
D408	Uganda (West Nile)	+ (3)	-	-
S9620	Uganda (West Nile)	+ (2)	+ (3)	-
S10053	Uganda	-	-	+ (4)
D411	Togo	+ (6)	-	-
D415	Upper Volta	+ (4)	+ (4)	-
D416	Upper Volta	+ (4)	+ (5)	-
D417	Senegal	+ (5)	+ (4)	-
S9392	Senegal (69)	+ (5)	-	-
S10066	Senegal	-	-	+ (5)
S9368	Sudan	+ (2)	-	-
S9687	Sudan	+ (5)	+ (5)	-
D477	New Caledonia	-	+ (3)	-
D487	New Cal.(ex Ivory Coast)	-	+ (6)	-
D522	Noumea New Caledonia	-	-	+ (4)
S10050	Ivory Coast	-	+ (5)	-
D480	Nigeria (Jos)	-	+ (6)	-
D486	Nigeria (Yola)	-	+ (5)	-
D500	Ghana	-	+ (5)	+ (6)

PROJECT: Evaluation of Teak (*Tectona grandis*)

Project Officers: **D. Reilly and B. Robertson**

Location: Douglas Daly Research Farm

Objective:

To evaluate a number of propagation methods to determine the most suitable for teak when planted in Blain soil type.

Recently there has been considerable interest in growing Teak in the NT and to determine the most suitable propagation method and soil type for its growth. In its natural state in Asia where it grows in mixed deciduous forests below 1,000 m, Teak is becoming a diminishing resource as reflected by its rapid decline due to high demand and ever-increasing price. Teak was included in many trials in the early years of Forestry Research in the NT. The trials were established on sites now known to be unfavourable for teak and where the risk of termite attack was very high. One such trial was established nearly 30 years ago at the coastal plains fringing forest near Fogg Dam for provenance screening. The nine provenances are still there despite poor survival of some trees within provenances that may be due to fire over the years.

Method:

DBIRD staff collected seed off the ground from this trial in mid 1998 and stored all seed together, as it could not be determined which seed was produced by which tree. The seeds of the nine provenances were bulked together, treated repeatedly with cool water and allowed to dry off for 10 days before sowing in open boxes filled with a mixture of sand and coco peat. Seedlings then received one of three treatments for planting in this trial. One group was propagated in 1 L plastic bags, another group was transferred to “Plantek” seedling trays, (capacity of each cell was 270 cc) and the third group was ‘open rooted’ where the shoots and roots are trimmed and the remaining stump is planted straight into the ground.

The trees were planted in blocks of 5 x 5 in the three different treatments and replicated three times. A two-row buffer was planted around the outside of the trial area using the same seed source. Trees were planted into ripped rows that had previously been sprayed with herbicide for pre-planting weed control. The rows were ripped at 3-m intervals and the trees planted every 2-m within the rows. Planting took place on two separate occasions. The first was on 17 December 1998 and the second on 28 January 1999. On 3 February 1999 each tree received 200 g of mixed fertiliser with trace elements. Measurements were first taken in August 1999 to indicate survival and growth. Survival and initial growth was good in the treatments with 1-L bags and 'Plantek' trays - 100% and 95%, respectively. In the 'stumped' treatment, survival was only 81% and this was attributed to the poor quality of planting material available. Many of the stumps were too small to be planted out but as the wet season progressed, time was running out for establishing a rain-fed trial. The poor growth in the treatment is shown in Figure 1.

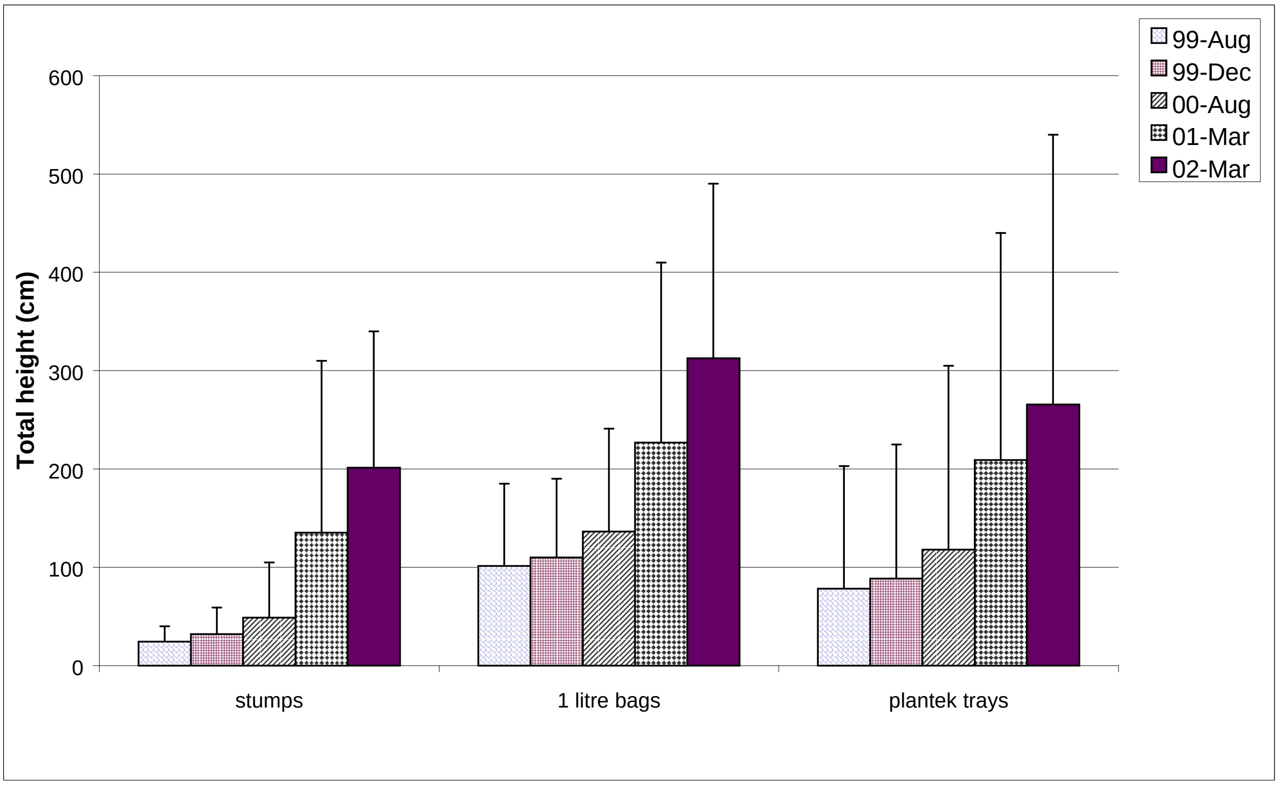

Figure 1. Mean growth of teak over a 39-month period at Douglas Daly Research Farm. Error bars indicate maximum height.

SUBPROGRAM: Livestock Management

PROJECT: Tenderbuff Development and Supply Project

Project Officers: B Lemcke, E Cox and L Huth and BHF Staff

Location: Beatrice Hill Farm

Objective:

To supply and promote the TenderBuff Quality Assurance program for local and interstate markets.

Background:

The TenderBuff program was initially started to provide higher returns to the producer whose buffalo numbers were small, post - BTEC. It was seen as a serious substitute for the feral fillet market to restaurants using a much larger range of cuts. The Agriculture Branch runs the project in conjunction with the NT Buffalo Industry Council and provides the personnel to do quality assurance and branding of carcases at the abattoir. The price remains at $3.10 per kg Hot Standard Carcase Weight (HSCW) paid to the producer. There are five specifications that a carcase must comply with to receive the TenderBuff strip brand.

With the destocking of CPRS, supplies are now sourced mainly from commercial properties and agisted at Beatrice Hill Farm to maintain a steady supply. With its extensive floodplain and ponded pastures, Beatrice Hill Farm is able to fatten stock all year round and is only a 45-minute drive from Litchfield Abattoir; well placed to supply the market. Few producers are yet able to turnoff directly into this market without using agistment to improve quality and weight for age.

Since March 2001, Beatrice Hill Farm has concentrated on producing TenderBuff, sending only non-conforming stock to the Brunei market.

As TenderBuff has lower cholesterol and fat than beef, the two factors can be used for positive marketing.

Method:

The current specifications are:

1. 150-300 kg HSCW.
2. 3-12 mm fat at p8 site.
3. No permanent teeth.
4. Electrically stimulated carcase.
5. pH of muscle after 18 hours below 5.8.

Agriculture Branch staff monitor TenderBuff animals through the abattoir on slaughter day and also carry out chiller assessment the following day.

The producer pays the abattoir kill fee of $70. The discount grid determines the sale price to the wholesaler of animals that do not comply with the 5 specifications.

Insufficient fat in Swamp males from agistment sources for the July to November period has been a slight problem in previous years. However, in the last 12 months all males have been castrated or made cryptorchid. This appears to have solved the low fat problem particularly in steers at lower weights or younger ages. There will be sufficient data to report any differences in live/dressed weight between the two treatments by the end of 2002. The males were treated to reduce the pregnancy rate in heifers in the group, which was complicating their turnoff times and markedly reducing their dressing weights.

Results:

Table 1. Carcase parameters for TenderBuff

	July-December 2000	January-June 2001	July-December 2001	January-June 2002
No of animals	10	26	29	39
Mean HSCW (kg)	163.9	193.6	200.6	217.2
Mean eye muscle area (cm^2)	46.2	53.7	52.6	56.5
Mean pH	5.57	5.63	5.62	5.62
Mean carcase length (cm)	96.5	99.4	102.0	103.6
Mean gross $	$503.55	$578.91	$579.38	$635.69
Mean grid $/kg	$3.07	$3.00	$2.90	$2.92
Mean p8 fat (mm)	4.6	8.3	6.7	6.3
Mean dressing %			48.9	50.2
% River cross	$^{2}/_{10}$ = 20%	$^{4}/_{26}$ = 15.4%	8/29=27.6%	2/39=5.1%

Table 2. Comparison between Swamp and 0.75 Riverine - for July 2001 to June 2002

	Swamp	¾ River	% Difference
No of animals	58	10	
Mean HSCW (kg)	209.0	216.7	8.5%
Eye muscle area (cm^2)	53.9	60.1	11.5%
Mean pH	5.61	5.7*	1.6%
Mean carcase length (cm)	103.0	102.4	-0.6%
Mean grid $/kg	2.94	2.80*	-4.8%
Mean p8 Fat (mm)	5.81	10.1	74%
Mean dressing %	49.5	50.7	2.4%
Mean price $	613.21	602.77*	-1.7%

* The above figures were adversely affected by two bulls with bad temperament; they had very high pHs and markedly reduced the mean grid price and mean price received. The means of the remaining eight animals for pH, grid and price were 5.56, $3.06 and $656.13, respectively.

The greater turn-off of river crosses in the dry season reflects their early turnoff and greater fatness, which makes year-round turn-off easier to achieve than in swamp purebred animals. Despite this, dressed weights of river crosses still exceeded those of the swamp animals.

It was pleasing to see an increase of 89% over the previous year, in the numbers that went to the TenderBuff market, which reflects the greater availability and an improvement in the quality of stock purchased from producers last year. It is still necessary to send a certain number of animals to the Brunei supermarket trade because of the appearance of permanent teeth in some animals before they reach a suitable live weight and fatness for the TenderBuff trade.

PROJECT: Ley Farming Systems Trial

Project Officers: **P. Shotton, R. Eastick, N. Hartley, B. Lemcke, L. Huth and DDRF Staff**

Location: DDRF

Objective:

To evaluate a sustainable farming system which integrates pasture, crop and cattle production.

Background:

An integrated farming system allows flexibility in the use of resources such as machinery and labour, spreads risk for commodity price changes and a crop/pasture rotation provides options for weed control and grazing management. This project incorporates a two-year pasture production phase (either Cavalcade only or mixed sabi/Cavalcade), grown in rotation with a one-year sorghum crop. In any season, there is a phase with sorghum stubble, a phase of first year newly establishing pasture, and a phase of second year established pasture. Weaners are introduced onto either the improved pasture or the sorghum stubble and weight gains are recorded over the dry season, aiming to reach a turn-off weight by the wet season. This grazing management and the crop/pasture rotation influences the plant population dynamics of the paddocks. Vegetation monitoring assesses these changes. In recent years, wet season utilisation of the mixed pasture paddocks has also been monitored in the belief that significant pasture productivity was being lost due to shading. Shading is likely to increase the proportion of low-quality dry understorey material in the sward saved for dry season utilisation.

The trial evaluates pasture and crop establishment, production and grazing management under no-till farming practices.

Method:

The 2001/2002 season weaner steers were introduced to the treatment paddocks on the 5 June 2001 whilst the 38 in the yearling group (2000-01 weaners) were allocated to their treatment paddocks on 21 May 2001. Cattle were weighed monthly. Phase 1 (paddocks 1-6) stock were grazing mixed pasture (paddocks 1-3) and Cavalcade only (paddocks 4-6) self re-sown one year after sorghum.

Phase II (paddocks 7-12) stock were introduced to sorghum stubble following Cavalcade only (10-12) and sorghum stubble following sabi/Cavalcade mixed (7-9) second year pastures and de-stocked after the first rains for paddocks 10-12.

Phase III (paddocks 13-18) contained second year self re-sown mixed sabi/Cavalcade pasture (paddocks 16-18) or Cavalcade only (paddocks 13-15) and were de-stocked in November prior to spraying and preparation for the no-till sorghum crop. Paddock 19 is yearly-cropped sorghum (half no-till and half under conventional cultivation).

Vegetation is assessed twice a year: April-May (at the end of the wet season prior to introduction of cattle) and November (at the start of the wet season). Botanal ® is used to record presence of species (percent weed and desirable species) and yield. Only mixed sabi/Cavalcade paddocks are stocked during the wet season.

The final cattle recording was on 21 March 2002 after which all paddocks were left empty until the smallest of the previous season’s yearlings were restocked on 23 May 2002. The new batch of weaner steers from Tipperary and was introduced to paddocks on 12 June 2002.

Results:

Cattle weight gains in the dry season and wet season are given in Table 1.

Vegetation
Sabi and Cavalcade once again regenerated well from the seed bank after the sorghum phase; however, early growth of summer grasses in the Cavalcade only paddocks necessitated an overall spray of glyphosate and a second regeneration of Cavalcade from seed reserves. This is never as satisfactory as the first germination, which should have been sprayed early with Spinnaker®. The sorghum crop this year was better established than in all previous years with much less growth of companion species (pasture and weeds). Birds were clearly a problem again during establishment and prior to harvest. They took a large proportion of the harvestable grain before the header.

Weight gain results
There is a trend again toward increased live-weight gains per head in those paddocks, which have low stocking rates or sorghum stubble. Animals in Cavalcade paddocks tend to gain weight well up until August but lose it quickly after that as feed quality and quantity deteriorate with increased temperatures, dew and early rains.

Table 1. Weight gain (kg/head) for yearlings and weaners during 21 May 2001 to 12 October 2001and weaner weight gains from 10 January to 20 March 2002, and total yields before commencement of grazing (kg/ha) for each paddock for May 2001

Paddock No	Pasture treatment	Stocking rate	Cattle weight gain (yearlings/ weaners)	Weaner wet season gains (2 head/ha)	Mean quadrat yields (kg/ha)
1	Mixed 1st year	Medium	-3.5/7.6	34.9	7624
2	Mixed 1st year	Low	12.5/16.6	48.2	9425
3	Mixed 1st year	High	31.0/11.0	55.6	10006
4	Cav 1st year	Low	41.5/32.3	NS	4703
5	Cav 1st year	High	36.5/25.7	NS	4360
6	Cav 1st year	Medium	5.5/27.5	NS	5801
7	Sorg/Mixed	Medium	27.0/2.6	34.4	8637
8	Sorg/Mixed	Low	17.0/4.2	37.2	6572
9	Sorg/Mixed	High	24.5/9.3	42.5	8495
10	Sorg/Cav	Low	39.5/31.6	NS	7895
11	Sorg/Cav	High	36.5/26.7	NS	5560
12	Sorg/Cav	Medium	32.5/26.0	NS	6796
13	Cav 2nd year	Low	39.5/36.3	NS	5713
14	Cav 2nd year	Medium	36.0/20.0	NS	6382
15	Cav 2nd year	High	27.0/22.2	NS	6296
16	Mixed 2nd year	Medium	11.5/9.6	NS	8624
17	Mixed 2nd year	High	8.0/8.3	NS	7662
18	Mixed 2nd year	Low	18.0/2.6	NS	9533
19	Sorghum continuous	Low	79.0/42.0	NS	8299
Mean all cattle			36.3/34.1	NS = not stocked in wet	

Sabi and Cavalcade again regenerated well from the seed bank after the sorghum phase in paddocks 7-9 although sabi constituted by far the largest percentage of the mix. In 10-12, weeds and summer grass were sprayed with Glyphosate® (45%) and Cavalcade was required to enact a second germination. In 2002 this was fairly sparse, because of the dry, short wet season.

All paddocks were de-stocked on the 22 October 2001 and bulk groups used to crash graze the pastures because they had to be planted to sorghum. On the 8 January 2002, weaners were grazed in mixed pasture paddocks at two animals/ha over the wet until 21 March 2002 in paddocks 1-3 and 7-9.

However the 38 lightest cattle were retained for restocking during the 2002 dry season.

There were some changes in trends in cattle performance over previous years, with the Cavalcade paddocks performing better than the mixed pastures over the dry. This may be due to the very low proportion of Cavalcade in these pastures by the time the dry season grazing commences.

Sorghum yield
During the 2002 wet season, sorghum was grown zero-till in paddocks 13-15 following Cavalcade pastures for two years and paddocks 16-18, which were mixed sabi/Cavalcade for two years. Machine harvest yields are given in Table 2. Paddock 19 is continuous sorghum cropping with 50% conventionally tilled and 50% zero-tilled.

Table 2. Sorghum yields

Paddock	Yield (tonnes/ha)
13	3.8
14	3.7
15	3.2
16	3.0
17	3.0
18	3.1
19 Conventional	2.3
19 Zero-till	2.3

Yields were the highest this year since the trial's commencement. This is a reflection of the better establishment of the sorghum (Mason planter) this year compared with most previous years. Bird damage to grain late in the season was still heavy. However, production in a sacrifice area in paddock 56, which was not equipped with scare devices, was reduced to around one tonne/ha. The overall average of all the seven paddocks of 3.05 t/ha is an excellent result when compared with the 1.78 t/ha last year. The conventionally tilled section of paddock 19 had to be re-sown after a heavy downpour of rain on the same day as planting. The replanted population turned out to be a little too high. The no-till area in 19 still carries an excessive amount of Pennisetum at harvest time but the total yield was still similar to the conventionally tilled block.

PROJECT: Riverine and Crossbreeding Buffalo

Project Officers: **B. Lemcke, E. Cox, G. Jayawardhana, the late T. Olm and BARC and BHF Staff**

Location: Beatrice Hill Farm and Berrimah Farm

Objectives:

To determine the merits of crossbreeding and upgrading to Riverine buffalo for the NT buffalo industry.

To distribute suitable progeny from the program to industry for breeding or for supply of tenderBuff

To demonstrate sustainable buffalo production systems.

Background:

It was the long held dream of pioneer buffalo researcher Don Tulloch to introduce Riverine blood into the Australian swamp buffalo population. The dream became reality in 1994 with the import of two bulls, followed over the next three years by a further four heifers and two more bulls. A crossbreeding program was started and progeny performance was monitored. Progeny were also put through the TenderBuff system. The purebred group has increased now to 26 head. Two of the imported bulls died, one accidentally and the other from TB three years ago. Also one calf died shortly after birth because the heifer did not have sufficient milk.

Method:

Purebred animals are held at both Beatrice Hill Farm and Berrimah Farm. Crossbreds are at Beatrice Hill Farm. Half bred cows and heifers are mated to the bull OJ and swamp cows are mated to the bull Hillary. The bull Bill who was exposed to TB infected cows, was trained to an artificial vagina and subsequently about 1200 straws of semen were collected from it and frozen in liquid nitrogen for later use. Some semen of Italian milking buffalo has also been imported into Australia. Semen from three bulls has been used in AI projects. Some of the purebred cows and ¾ heifers have been inseminated with Italian semen.

Results:

Table 1. The composition of Riverine and crossbred buffalo at Beatrice Hill Farm, June 2002

	Imported bulls	**Local bulls**	**Cows**	**Yearling bulls**	**Yearling heifers**	**Male calves**	**Female calves**	**Total**
Purebred Riverine	2	2 (2 sold)	13	1	6	1	1	26
Swamp		-	26	-	-	1	0	27
F1		-	27	8	13	1	0	49
3/4		4 (1 sold)	28	10	14	7	4	67
7/8		2*	1	2	2	9	9	25
15/16						1	0	1
TOTAL	2	8	95	21	35	20	14	195

This is the first year calving after the introduction of controlled mating. The productivity of F1 cows was considerably lower this year. It is expected that this will only be a short-term anomaly as the breeders adjust to the changed breeding period in the next season.

Three bulls were sold this year - two pure Riverine (one to NSW and one to Victoria) and one ¾ to NSW. These are the first Australian-born purebred animals to be sold.

The success rates of artificial insemination have again been disappointing. This is despite using the Brazilian protocol, which reputedly has a 50% success rate on single inseminations. Results from the insemination attempts will not be known until calving dates are known, due to the use of back-up bulls, and the uncertainty in aging buffalo foetuses at a first trimester pregnancy test.

Of note this year is the birth of the first 15/16 calf in the project. It is a male and will be weaned in October 2002. Also for sale are two 7/8 bulls which are by AI using Italian semen. Arrangements have also been made for the supply of 20 F1 cross heifers, the purchase of 10 ¾ heifers, and three purebred Riverine heifers to go to a dairy farm in Millaa Millaa, Queensland. A cooperative agreement has been signed to obtain milking data on the various crosses and pure breeds. The F1s will remain the property of the NT Government and progeny will be shared 50:50.

PROJECT: Pasture Species Evaluation under Grazing at DDRF

Project Officers: B. Lemcke, P. Shotton, N. Hartley, L. Huth and DDRF Staff

Location: Douglas Daly Research Farm

Objectives:

To evaluate pasture species and mixtures under a continuous grazing regime on Blain soil at DDRF.

To determine their persistence, productivity and contribution to the performance of cattle.

Background:

Promising pasture introductions are evaluated under grazing at DDRF to determine their long term potential in the Douglas Daly environment.

Method:

The pastures are grazed in 4 ha paddocks by five Brahman weaner steers per paddock (1.25 animals/ha). The exception is paddock 49, which had five extra animals to increase the stocking rate to 2.5 animals/ha to utilise the excessive amount of grass that had built up in the paddock in recent years. Steers are allotted to paddocks in June/July (post weaning) and remain in the grazing trial until the following June.

Paddocks are top-dressed annually with a phosphorus-based fertiliser. This year Goldphos 20® was spread on the paddocks at 70 kg/ha. During the wet season, various weed control measures were undertaken where required, usually spot-spraying for broadleaf weed control. Some grass only paddocks are boom-sprayed with Starane/2.4-D mixtures if broad leaf weeds are prominent. Paddock 52 (Oolloo/Arnhem) was sprayed to control sida, but Oolloo was eliminated as well. A single application of 90 kg/ha urea was made to paddock 44 (pangola), paddock 45 (pangola), paddock 46 (sabi) and paddock 47 (Jarra) because they had shown symptoms of nitrogen deficiency in previous years.

The animals are supplemented with ad-lib Uramol® blocks during the dry season and with Phosrite® blocks in the wet season. Intake was recorded monthly.

Cattle were weighed monthly, given a condition score and P8 (rump) fat was measured, starting in late December and continuing till the end of the grazing season in June 2002.

Pasture composition and yield were assessed twice during the year, in early wet season, during December 2001. A post-wet season assessment was made in May 2002.

Paddock 50 was sown with a range of legume species to determine the most appropriate to complement the existing buffel grass (see Project - *Pasture Species Evaluation under Grazing at DDRF* - Paddock 50).

Paddock 50 contains four blocks of multiple plots of five legumes sown into buffel grass during December 1999. It was grazed continuously throughout the period July 2001 – June 2002

First grazing of re-established paddocks 48 and 50 commenced in July 2000. Paddock 48 contains three rows of Cunningham and three rows of cv Taramba leucaena, which were slashed in November 2000 to a height of 30 cm and destocked till January 2001. Again in December 2001 the rows were again slashed low, and the stock remained in the paddock. Each leucaena row is half the paddock in length.

A new paddock (No. 42) was established during this wet season with Wynn Cassia. It was treated for grass and broadleaf weed control to maintain a high proportion of Wynn cassia. Grazing commenced in March 2002. This is one element of a district PIRD project on Wynn cassia productivity.

Because of increasing broadleaf weed problems below the leucaena rows, paddock 44 was rehabilitated by removing all the leucaena and re-establishing pangola runners in the row spaces.

At the same time paddock 45 was planted with five rows of three varieties of leucaena. This paddock was de-stocked until the new weaners were introduced in June 2002.

Table 1. Mean cattle live-weight gains (kg/head)

Paddock No./ ** statistical significance	**Pasture type**	**July 01- Oct 01 Late dry**	**Oct 01 - April 02 wet season**	**April 02- June 02 Early dry**	**TOTAL July 00- June 01**
42	Wynn cassia	NA	NA	-2.4	NA
43 a,c	Higane (P. atratum)	23.9	138.8	34.6	197.3
44	Leucaena/pangola	40.5	NA	NA	NA
45	Pangola/+ 90 kg urea	20.3	NA	NA	NA
46 a,b	Sabi/+ 90 kg urea	0.1	144.0	9.6	153.7
47 a,c	Jarra/+ 90 kg urea	3.7	145.8	23.6	173.1
48 a,c	Kaz setaria/sabi/leucaena	13.3	130.8	32.8	176.8
49 b	Buffel/blue pea	0.6	141.2	12.3	154.1
50 a,c	Buffel/legumes	27.0	140.5	40.5	208.0
51 a,c	Strickland/Wynn	9.0	156.8	25.0	190.8
52 b	Arnhem/Oolloo	-6.3	115.2	3.2	112.1
531 a,c	Buffel/sabi/LNT blocks	5.5	154.8	22.4	182.7
532 a,c	Buffel/sabi/4 Seasons	9.7	158.8	19.0	187.5
533 a,c	Buffel/sabi/Wynn	8.3	150.6	19.2	178.1
534 c	Leucaena/buffel/sabi	25.0	153.6	28.8	207.4
	Mean Live-weight change				173.0

** Groups with the same letter are not statistically significantly different at the 5% level (Bonferroni Test).

Table 2. Mean cattle live-weight gains per head for four years

Year	**1998-1999**	**1999-2000**	**2000-2001**	**2001-2002**
Live-weight gain	190.4 kg	187.7 kg	176.1 kg	173.0 kg

An attempt to re-sow Oolloo in paddock 52 in January 2002 failed due to dry conditions, insect damage and grass competition.

It is significant to note that paddock 49 has the highest production per hectare of all the paddocks in the trial area. Whilst the higher stocking rates are depressing individual animal gains, the paddock production is still rising. This year it reached 385 kg/ha of live-weight gain. It would probably be achievable in other paddocks as well if they were stocked to maximise production per hectare. The long term problems of overstocking cannot be overstated and therefore conservative stocking rates are used in this trial for comparison purposes. There has been a steady decline in the amount of feed in paddock 49 with the increasing stocking rates, but it is not yet at a critical level to cause concern about its longevity.

Block consumption
In the dry season, Uramol® was fed from 21 June to 17 October 2001 and in the wet season, Phosrite® was fed from 18 October 2001 to 28 June 2002 to all paddocks. Paddocks 531 and 532 consumption in the wet did not start till 13 November 2002, due to the delay in arrival of the second brand of block.

Table 3. Dry and wet season daily consumption rates of supplement

Paddock	Dry season consumption (Uramol) g/head/day	Wet season consumption (Phosrite) g/head/day
Period	**118 days**	**253 days**
42	NA	
43	71	80
44	53	NA
45	92	NA
46	66	100
47	81	127
48	95	75
49	142	135
50	86	96
51	89	106
52	120	73
531	87	135 *
532	149	104 *
533	69	94
534	92	83
Mean 01/02	92 g/head/day	101 g/head/day
Mean 00/01	78 g/head/day	85 g/head/day
Mean 99/00	81.8 g/head/day	75.5 g/head/day
Mean 98/99	102.0 g/head/day	89.3 g/head/day
Mean for 1997/98	134.3 g/head/day	119.3 g/head/day

* These two groups consumed block for 227 days only.

Consumption rates per head of Uramol® increased slightly over the previous two years, whilst for Phosrite® there was a further increase over last three3 years' intake.

Block comparisons
Again this year an attempt was made to compare blocks from different manufacturers. The Four Seasons Company supplied wet and dry season formulations to compare with Uramol® and Phosrite® previously used over the long-term in this trial.

"Pro90®" was used in the dry season for the group with number 532 ear tags. Their wet season block was "Big P®". The Big P® blocks did have better wet season durability this year than the previous formulation used last year. The Pro90® dry season block group produced twice the weight gain of the Uramol group (9.7kg live-weight gain vs 5.5kg live-weight gain for the total dry period) but had a 71% higher consumption rate than that of the Uramol® block.

Wet season consumption of blocks by the two groups was the reverse with Phosrite being consumed at a rate 30% higher than the Big P®. The live-weight gains were slightly higher for the Big P® group (4kg/head) but this difference was not statistically significant. Uramol® consumption rates for the control group were only slightly lower than the mean for all the groups.

The average cost of block for the year at the average consumption rates per head were as follows:

Wet season	$22.80	8 months
Dry season	$10.20	4 months
TOTAL	$33.00	12 months

Based on prices per tonne of Phosrite® - $961.00 and Uramol® - $925.00

PROJECT: Soil to Plant Uptake of Radioactivity

Project Officers: P. Shotton (DBIRD) and J. Twining (ANSTO*)

Location: Douglas Daly Research Farm

* Australian Nuclear Science and Technology Organisation

Objective:

To determine the amount of radioactivity that may be taken up by cultivated plants used for animal and human consumption.

Background:

Nuclear power will have a role in the rapid industrial development occurring in the tropics, particularly given the need to reduce global greenhouse gas emissions and the increasing need for electricity. Hence, accurate and precise predictive models of radiological dose in tropical and sub-tropical regions of the planet are required should there be any atmospheric release of radioactive material. From ANSTO's perspective this is particularly relevant for the northern areas of Australia and across South East Asia. The data from this study will contribute significantly to the current low-level of knowledge we have of the behaviour of these materials in tropical regions, particularly as the soil types being used are representative of large areas of agricultural regions within the tropics. The overall aim is to provide better emergency response planning but the study will also contribute to our understanding of general elemental biokinetics in crops.

Method:

This study is conducted to evaluate radionuclide transfer factors under tropical Australian conditions and to evaluate the factors that control that process. Two plots have been established on Blain and Tippera soils. Radioactivity (caesium-134, strontium-85 and zinc-65) was first added to the plots in October 1999. Additional Sr-85 was added in October 2000 and again in October 2001 (This isotope decays away each year). Sorghum and mung beans have been sown at the beginning of the wet season and harvested in March and April while the third season's crops were to be harvested by April 2002. The latest set of crop samples has not yet been analysed completely. The following results come from the analysis performed over the second year of the study.

Location selection and site preparation occurred 1999. Fences and enclosures were completed in October 1999 and the areas pre-watered and the first treatments applied on 15 October 1999.

At each site:	Actual treated areas	30 m^2
	Enclosed area	110 m^2

Quarantine areas 2,500 m^2

All areas were applied with recommended fertilisers, planting rates, weed control herbicides and insecticides when required. Water was applied to the areas to assist with establishment. Strontium (85 Sr) is applied to both sites each year in October. Both sites are hand harvested, taking grain and plant material from both treated and non-treated areas and sites. Soil samples are collected from each site at three depths during yearly plant harvest and at labelling.

Results:

The radioactivity is strongly bound to the soil surface and is migrating into the soil very slowly and more than 90% of the radioactivity remains in the top 5 cm (most within the top 3 cm). The small degree of depth penetration is surprising given the amount of bioturbation seen at the sites and given that two crops have been grown on the sites. No substantial differences in radionuclide retention between the two soils have been observed. In addition, the amount of radioactive material in the soil is approximately the same at harvest in 2001 as when it was added originally (within errors after accounting for radioactive decay). This result indicates that very little of the material has moved from the sites (Table 1). These results can be used to show the value of the zero-till methods used in keeping soil loss to a minimum.

Table 1. Average specific activity in each soil by depth (Bq/kg DW). **a.** At time of labelling (October 99) and **b.** At time of harvest 18 months later (April 2001).

Sample	Type Depth	Blain ^{85}Sr	Blain ^{134}Cs	Blain ^{65}Zn	Tippera ^{85}Sr	Tippera ^{134}Cs	Tippera ^{65}Zn
a							
At label	0 - 5 cm	2330	3843	4940	2093	3597	4477
1999	5 - 10 cm	86	200	184	105	185	210
	> 10 cm	22	47	35	37	66	69
b							
At harvest	0 - 5 cm	2472	5383	4983	2024	3350	3897
2001	5 - 10 cm	163	34	287	368	552	611
	> 10 cm	42	13	71	Not sampled		
		To 1/10/00			To 1/10/00		

Activity is corrected for decay to 1 October 1999 except Sr-85 at harvest to 1 October 2000.

The results for the first two sets of crop harvests are compared in Table 2. These show that plants adjacent to the labelled areas do take up some small proportion of the activity, probably by root penetration into the active area. Crops sown further away from the activity have lower levels (more detailed data not shown here; it is available from Mr. Twining). For the plants growing in the areas labelled with radioactivity, mung beans generally accumulated more radioactivity than the sorghum. Both crops took up slightly more radioactivity from Blain than from Tippera. Comparison between years suggests that accumulation is becoming less with time, particularly in Tippera. This result is expected. The radioactivity is anticipated to bind more strongly with the soil particles and hence be less available to the plants as time progresses. This effect is more noticeable in clay soils and so the result for Tippera is consistent with this pattern.

Table 2. Average specific activity (Bq/kg DW) in each crop type, from labelled and unlabelled areas and by soil type

Soil Crop	**Blain** ^{134}Cs	^{85}Sr	^{65}Zn	**Tippera** ^{134}Cs	^{85}Sr	^{65}Zn
Mung bean						
Labelled 00	186	2040	22400	86	1810	16500
Labelled 01	88	2233	22400	33	1320	12100
Unlabelled 00	<0.4	<6	107	4	<3	360
Unlabelled 01	<0.4	<5	113	<1	8	62
Sorghum						
Labelled 00	68	404	18700	74	343	10500
Labelled 01	47	270	9590	24	88	6490
Unlabelled 00	2	26	1300	1	5	54
Unlabelled 01	<1	3	9	<1	2	64

Radioactivity is corrected for decay to 1 October 1999 (1/10/00 for Sr-85)

The results for Cs and Sr are typical for these elements and are now trending towards the lower end of the expected range for these types of crops based on previous data from temperate areas. The uptake of zinc however, is about 10 – 20 times higher than expected. The study will extend over at least one more growing season (2002-2003) to look at the effect of soil adsorption on plant uptake as well as the other factors (pH, moisture content, nutrient status, etc) that are likely to influence bio-accumulation.

A background to the study and more detailed results are available in ANSTO report number REPP-TR-01 and any subsequent publications.

PROJECT: Weed Management Strategy Demonstration Site

Project Officers: R. Eastick, P. Shotton, B. Lemcke and DDRF staff

Location: Douglas Daly Research Farm

Objective:

To demonstrate a 'best bet' pasture rehabilitation/ weed management strategy on a severely weed infested Cavalcade paddock

Background:

The area had been established with Cavalcade pasture for a number of years, prior to the start of this project. It had become infested with weeds resulting in poor productivity. This project aimed to demonstrate a strategic weed management plan involving a five-year crop/pasture rotation. It will evaluate the increase in productivity of the pasture each year, and ultimately enable the area to be re-sown to cavalcade.

Method:

The total paddock area is approximately 6 hectares.

1995/96
The area was under Cavalcade with large amounts of weeds, particularly sida, senna and hyptis.

1996/97
The area was cultivated, sown to Jumbo sorghum, applied with pre- and post- emergent atrazine, fertiliser (200 kg/ha of 0-18-0-10) and eventually harvested in early April. No nitrogen fertiliser was required. Yields of 12 t/ha of hay were achieved.

1997/98
The area was cultivated and sown to sabi (6 kg/ha of hulled seed) in mid-January, and fertilised at 37 kg/ha Pasture Gold ® 0-14-0-17 + trace. Sabi established well. Broadleaf weeds also emerged, so the area was sprayed with Diuron ® at 4 L/ha in mid March.

1998/99
Cattle were introduced on 17 June 1998 at five to 0.8 animals per hectare. They were grazed continuously except for a two- week period in January (6-20) when the pasture was fertilised with 100 kg Pasture Gold 0-14-0-17 and sprayed with 2 L/ha Diuron and 2 l/ha 2,4.D Amine (to control broadleaf weeds). On 28/1/99 two extra steers were put in Bay 11 (both 234 kg; raising the stock numbers to 7 head on 6 ha).

1999/2000
Cattle were replaced on 10 August 1999 with five weaner heifers, which were continuously grazed on the paddock through to 30/6/00 except when de-stocked for spraying. Cattle weights were recorded every two months. Cattle received ad lib access to wet and dry season supplement blocks. A group of approx 30 bulls was used to crash-graze the paddock in January 2000 whilst heifers were removed prior to spraying with 2 L/ha each of Diuron and 24D on 8 February 2000. Heifers were brought back to the paddock on 17 February 2000. They remained in the paddock until November 2000.

The paddock was pasture surveyed using Botanal in May 1997 (after harvest), November 1997 (to monitor emerging weeds with the start of the Wet), February 1998 (to record sabi establishment and weeds emerging) and June 1998 (to record pasture species population before cattle were introduced). Botanal pasture surveys were also carried out in November/December 1998, 1999, 2000, 2001 and in May 1999, 2000, 2001 and 2002.

November 2000
Two 1.2ha plots were pegged and had the following treatments:

Plot 1 (No-Till Plot)

Glyphosate 4 L/ha on 19 December 2000.
Fertilised with 100 kg/ha of Goldphos 20® pre-planting.
Planted with 10kg/ha Cavalcade seed (Buffalo Planter).
Pre-emergent application of Spinnaker ® 0.4l/ha on 19 December 2000.

Plot 2 (Conventional Tillage Plot)

Glyphosate 4 L/ha on 19 December 2000.
Ploughed 12 December and again on 16 December 2000.
Planted 10kg/ha Cavalcade seed with 10kg/ha of Goldphos 20 ®.
Applied Spinnaker ® 0.4L/ha pre-emergent on 19 December 2000.
Rolled herbicide using Glyphosate® 1:7 mixture with water on 7 March 2001. Pasture topped using slasher at 0.4 metre height

Wet season 2001-02
Cavalcade area was sprayed with Glyphosate 45® at 4 L/ha on 8 December 2001 and Spinnaker 700WDG® at 120 g/ha on 19 December 2001. The Cavalcade was slashed to encourage regrowth on mature senna plants not affected by previous sprays on 31 December 2002. The paddock was fertilised with Goldphos 20® on 4 January 2002 whilst the sabi area was sprayed with Diuron 90% at 2.5 L/ha plus 2.5 L/ha 2.4-D (62.5%). It was also sprayed with Verdict®(52%) at 150 mL/ha on the Cavalcade area on e 28 February 2002. Herbicide rolling also occurred on 4/3/02 using Glyphosate® at 10:1 with LI700 wetter for senna control.

Results:

Despite such a long weed-free period (five years of treatment) a considerable amount *of Senna obtusifolia* and *Corchorus aestuans* emerged along with buffalo clover and some annual grasses. This was much higher in the conventional tillage plot (CT) than in the no-till plot (NT) where weeds only appeared in sites where wild pigs had previously been digging. In the 2001-02 wet season the main emergence initially was sabi grass, which swamped everything including small amounts of Cavalcade. Weed growth still occurred and needed to be treated if the area was to have been used for haymaking. However, the paddock was grazed by six Brahman yearlings for the full year, except when spraying herbicide. Cattle growth was as follows:

Mean weight gains (one animal/ha)

Dates	Weight gain (kg)
22/6 - 14/8/01	20.3
14/8 - 8/1/02	77.2
8/1 - 15/5/02	90.0
15/5 – 23/6/02	22.6
TOTAL one year	**209.1**

This is an excellent weight gain for 12 months and reflects the availability of Cavalcade for dry season nutrition, that is, mixed grass/legume pasture. The area was not grazed during the full wet season.

PROJECT: Weed Control Using Herbicide Rolling and Slashing Methods

Project Officer: **P. Shotton**

Location: Douglas Daly Research Farm

Objective:

To trial, monitor and record the short and long term effectiveness of weed control methods in pastures using herbicide rolling and slashing techniques.

Background:

The control of grass and broad leaf weeds in pastures is an ongoing concern, particularly where selective herbicides are not available or are uneconomic. With the use of selective herbicides, various grasses and broad leaf weed species can be controlled in pure stands. However, the control of weeds in mixed pastures, such as grass weeds in grass pastures and various broad leaf weeds in legume pastures is more difficult with minimal selective herbicides available to our knowledge, or their expense cannot be justified.

Herbicide wipers are one method being used for managing taller weeds in crops and pastures world-wide, with varying success depending on location, weed species, application methods and chemicals used. The benefit of herbicide rollers is that the chemical is only applied to the target weed, so wastage is minimal and spray drift is eliminated. Mechanical means for weed management such as slashing, is a commonly used practice to reduce weeds, plant biomass and reduce seed set.

Method:

A replicated herbicide wiping trial was conducted at Ruby Downs Station in March 2002 using three different chemicals and two surfactants on sida *(Sida acuta)* and sickle pod *(Senna obtusifolia).*

Glyphosate 450® (Glyphosate 450 g/L)
Brush Off® (Metsulfuron Methyl 600 g/kg)
Grazon ® (100 g/l picloram and 300 g/L Triclopyr)
One thousand wetter® Spray wetter (1,000 g/L alcohol ethoxylates
LI 700® (345 g/L soyal phospholipids and 355 g/L propanoic acid).

Application
Treatments were applied on the 15 March 2002 and 16 March 2002 using a carpet herbicide roller. Each treatment was applied to the six replications by mixing the chemical mix and wiping each plot then washing the herbicide roller down to remove previous chemical residues prior to applying the next treatment. It is difficult to determine the actual amount of chemical fluid applied per hectare, particularly on small plots as different plant species, plant height and plant density will be quite variable. Past experience indicates a 100% wiping rate will use 35 to 45 litres of fluid per hectare; therefore, 40 litres of it was used on the trial area.

Treatments
The treatments used for each consisted of the product plus percentage of rain water together with the percentage of the surfactant used.

T1 Glyphosate 450® @ 1 part chemical product to 10 parts water plus wetter @ 2%
T2 Glyphosate 450® @ 1 part chemical product to 10 parts water plus LI 700® @ 2%
T3 Glyphosate 450® @ 1 part chemical product to 5 parts water plus wetter @ 2%
T4 Glyphosate 450® @ 1 part chemical product to 5 parts water plus LI 700 ® @ 2%
T5 Brush Off® @ 1 g product to 1 litre water plus wetter @ 2%
T6 Brush Off® @ 1 g product to 1 litre water plus LI 700 ® @ 2%
T7 Grazon ® @ 1 litre product to 15 litres water plus wetter @ 2%
T8 Control

Results:

The effect of each treatment was rated on 28 March 2002 and again on 9 May 2002. Trial data is currently being analysed. From observations, each of the seven treatments used had varying degrees of success depending on the weed species. To date, the most universal chemical has been Glyphosate® with 2% LI700®, which killed or affected both target weeds. The stronger chemical solution mix (1: 5) produced the best results. Grazon® worked well on senna; however was not as successful on sida. Other trials and observations have also shown that Glyphosate® has been successful in controlling a number of other broad leaf and grass weeds in improved pastures and fodder crops.

The major contributing factor for effectiveness has been the height and density of the weed mass and the speed of application, which affects the transfer of chemical solution to the target weeds. Generally the taller and more leafy the weeds are, the greater is the effect due to greater chemical contact.

PROJECT: Pasture Species Evaluation Under Grazing at DDRF - Buffel /Legumes

Project Officers: **P. Shotton and B. Lemcke**

Location: Paddock 50, Douglas Daly Research Farm

Objective:

To monitor the value of a companion legume with buffel grass in terms of nitrogen availability, pasture quality, quantity and the persistence of the legume species.

Background:

Buffel grass is a commonly used improved pasture in the Top End, south of and including the Douglas-Daly region. As established buffel grass pasture tends to grow in clumps, a favourable legume companion species would be beneficial to help utilise the area between the buffel plants and ideally provide nitrogen to the grass resulting in higher quality and better yielding pastures. A higher protein diet for cattle due to the legume, would be an added bonus.

The project follows an ungrazed plot trial in 1996-1998 that evaluated the benefits of six tropical pasture legume species as companions to buffel grass *(Technote* 110).

Method:

On 6 January 2000, seeds of five pasture legume species were planted in paddock 50 at DDRF. The area was lightly disturbed using a trash worker cultivator to encourage seed to contact soil after crash grazing.

Trial area: 4 ha

Treatments: Control -- buffel only *(Cenchrus ciliaris)*
Wynn cassia *(Chamaechrista rotundifolia)*
Verano stylo *(Stylosanthes hamata)*
Oolloo *(Centrosema brasilianum)*
Maldonado *(Macroptilium gracile)*
Milgara Blue pea *(Clitoria ternatea)*

Plot layout: four replicates, each randomised.

Plot size: 130 m x 12 m

Fertiliser: 50 kg/ha Goldphos 20 – December 1999 and again in December 2001
45 kg/ha 0-11-0-14 applied at seeding.

Weed control: Broad leaf weeds were controlled by using Starane® as a post planting / pre-emergent herbicide.

Grazing: No grazing was allowed during establishment in the first wet season to allow legumes to set seed.

Recordings: Botanal –In each plot botanal was used to determine plants present and the percentage of each and pasture yield. (November and May each year).

Soil and plant samples are taken from each plot to compare the differences in soil and plant nutrients and to provide quadrat cut measurements to construct regression equations for botanal estimates.

Results:

During the first season, all legumes established well. The most prolific were Milgara Blue pea, Oolloo and Maldonado. Wynn cassia and Verano stylo were less prolific than the twining legumes. Verano, Wynn and Blue pea seeded well although Oolloo and Maldonado seeded poorly. During the second season, all legumes again established and grew well. Results from the April 2001 harvest yields showed that the greater the legume content, the higher was the overall yield, but grass yield was lower. Oolloo mix had the highest overall yield and the control had the lowest overall yield.

The April 2002 Botanal found that the percentage of legume in all treatments was much lower compared with the previous year. Total yields of each were also much lower probably due to the lower rainfall that wet season. Oolloo again produced the highest total yield with a 35% legume content. Other treatments produced reasonable yields; however the legume percentage was much less. At the end of the third wet season, results from the biomass harvests suggest that the higher the proportion of legume content, the higher is the nitrogen in the companion buffel grass.

PROJECT: Evaluate the Benefit of Wynn Cassia as a Pasture Feed and Fodder Species in the Douglas Daly District

Project Officers: **Douglas Daly PIRD Group, P. Shotton, F. O'Gara and B. Lemcke**

Location: Paddock 42 and 10A - Douglas Daly Farm

Objectives:

To monitor the performance of cattle when grazed on a pure stand of Chamaechrista rotundifolia (Wynn cassia) in terms of weight gain, condition change and fatness.

To monitor the persistence of the pasture and the suitability of Wynn cassia as a fodder.

Background:

Through past farm walks and general discussion, producers in the Douglas Daly district had concerns of the benefits of Wynn cassia as a pasture species. Because there was no distinct answer to many of the questions asked about the species, the district producers and community started a Producer Initiated Research Project (PIRD) to look at some of the issues.

The main issues being raised was the palatability of Wynn cassia; its benefit as a companion legume for nitrogen fixation, the ability to fatten cattle; its threat of becoming a weed; feed quality and potential yields for grazing and fodder production; and its fertiliser requirements.

Method:

As part of the species evaluation trial, a 4 ha paddock (paddock 42) was set up as pure stand of Wynn cassia to monitor the performance of steers over a 12-month period. The area was sprayed with a knock down herbicide in November 2001 and planted with Wynn cassia at 6 kg/ha early in December using zero till planting methods. Goldphos 20® fertiliser was applied at 150 kg/ha pre planting and 50 kg/ha Muriate of Potash was applied post planting.

Spinnaker® and Verdict® herbicides were used to control grasses and some broad leaf weeds as well as significant amounts of hand weeding of broad leaf weed species was done.

Observations
On 7 March 2002 five steers with live-weights between 280 – 380 kg were put in the almost pure stand of Wynn cassia. All animals were weighed each month with the other species evaluation trial animals. Visual condition and P8 fat was also measured and recorded. On 28 June 2002 the original five steers were replaced with five weaner steers as part of the standard 12 month grazing change-over for the trial.

Results:

Establishment of the pasture was slow, eventually thickening up later in the wet season.

During the first month of grazing the steers put on weight averaging 0.8 kg/head/day. The following two months showed little or no weight gain and the last weighing showed four of the five steers had lost weight of between 5 to 15 kg over the month. From 28 June 2002 to 24 July 2002, four of the five new weaner steers had gained an average weight of 0.1 kg/head/ day.

PROJECT: Grain Sorghum Varieties for the Douglas - Daly District

Project Officer: **P. Shotton**

Location: Douglas Daly Research Farm

Objective:

To grow and trial new and commercially available grain sorghum varieties at the Douglas Daly Research Farm and monitor which varieties are suitable for the Douglas - Daly District.

Background:

Over the past eight years replicated sorghum variety trials have been undertaken at the Douglas Daly Research Farm. During the past five years, sorghum seed has been used and supplied by the Pioneer and Pacific Seed companies. Varieties that are evaluated are those that have shown promise in past years and new varieties that may suit Top End conditions. Trial results will provide information for Top End sorghum producers to choose which commercially available seed varieties are the most suitable.

Method:

Trial location: Systems trial paddocks 13 to 17 at DDRF

Trial area: 4 ha

Varieties: 13 with 5 replications.

Plot size: 100 x 3 metres.

Weed control: Glyphosate® @ 2.5 L/ha
Atrazine 500® @ 2 L/ha
Dual Gold® @ 1.5 L/ha

Fertiliser: 180 kg/ha N.P.K.S & T.E. (16-18-0-12)
90 kg/ha urea
90 kg/ha Muriate of Potash

During November 2001, the paddocks to be planted were sprayed with a knock-down herbicide (Glyphosate®) to kill all pasture present and to prepare for zero-till planting.

On 18December 2001 the sorghum varieties were planted and fertilised using an eight row zero-till planter.

Pre-emergent herbicides (Atrazine 500® and Dual Gold®) were applied by boom spray on 20 December 2001 for the control of various grasses and broad leaf plants. The trial area was top-dressed with urea on 22 December 2002.

Observations
Each plot is monitored and evaluated for plant population, insect and pest occurrence, plant height, head type, resistance to head mould and leaf disease, plant lodging, hand and machine harvest yields, flowering and maturing dates.

Results:

The following are the results of the 2001 - 2002 grain sorghum evaluation trial conducted at the Douglas Daly Research Farm, NT (13° 50' S, 131°10' E).

This time we had a good start to the wet season, despite some dry conditions during plant emergence and some flooding in February. Most of the sorghum grew well and provided high yield.

Total rainfall for the season was 1,144 mm.

This season the trial was incorporated with the Systems Research Trial where sorghum is grown for one season after two years of pasture. The two pastures prior to the sorghum were a legume; predominantly *Centrosema pascuorum* (Cavalcade) and a mixed pasture of sabi grass (Urochloa pullalans) and Cavalcade.

The highest yielding varieties this year were "Maxi", "MR43","8118", "Bonus" and "Graze N Sile" producing between 5 and 6.5 tonnes/ha, hand harvested.

Sorghum variety trial 2001-2002												
Systems paddocks 13 to 17 Douglas Daly Research Farm												
Seed company	Sorghum variety	Average first flower DAP	Average 50% flower DAP	Average head type (O,SO,SC, C)	Average height	Average head mould	Average head exert	Average lodging 1 to 5	Average leaf disease	Average plant population	Average HHY at 13% moisture	Krondomic weight
Pioneer	85G83	62	67	SC	1.3	3	1	5	3	64,700	4,324	77.5
Pacific	Buster	56	62	SO	1.3	3	3	5	3	95,700	4,970	78.5
Pacific	Maxi	56	62	SO	1.4	4	4	5	3	119,700	5,282	78.0
Pioneer	82G55	67	71	C	1.7	3	2	5	4	63,900	4,772	79.0
Pioneer	8118	63	69	SO	1.5	4	3	5	3	88,800	5,537	83.0
Pacific	Pacer	55	60	O	1.3	3	3	5	2	111,300	4,646	76.5
Pacific	MR43	59	63	O	1.3	3	2	5	3	103,800	5,629	78.5
Pioneer	Graze N Sile	65	69	C	2.1	4	3	4	3	83,300	6,477	81.5
Pioneer	Jackpot	61	65	C	1.4	3	4	5	4	67,300	4,939	78.0
Pacific	MR32	51	56	SO	1.3	3	3	5	2	93,300	4,494	81.0
Pacific	Chopper	65	71	C	1.9	4	2	4	3	31,900	3,340	81.0
Pioneer	Bonus	65	69	SC	1.4	4	3	5	4	79,200	5,599	80.0
Pioneer	8586	61	65	C	1.3	3	2	5	3	78,200	4,935	81.0

Head Type

O = Open
SO = Semi open
SC = Semi closed
C = Closed

Lodge

1 = Severe lodging
5 = No lodging
DAP = Days after planting
HHY = Hand harvested yield

Head Exertion

1 = Poor exertion
5 = Good exertion

Leaf Disease

1 = Severe leaf disease
5 = No leaf disease

PROJECT: Douglas Daly Research Farm Weather Recording

Project Officers: P. Shotton, C. Lamond, DDRF Staff and Bureau of Meteorology

Location: Douglas Daly Research Farm

Objective:

To observe, monitor and record daily weather information from the Douglas Daly Research Farm manual and automatic weather stations.

Method:

Meteorological observations include the 9 a.m. cloud type and amount, visibility, evaporation, wind run, wet and dry bulb temperatures, minimum and maximum temperatures, past and present conditions and rainfall.

The automatic weather station records the following every 10 minutes, hourly and three hourly: wind run, wind speed and direction, dew point, wet and dry bulb temperatures, minimum and maximum temperatures, rainfall and barometric pressure.

Results:

All past DDRF weather information has been recorded and is available on request. Daily weather data is also sent to the Bureau of Meteorology.

PROJECT: Multibreed Composite Assessment

Project Officers: G. Jayawardhana, the late T. Olm, P. O'Brien, C. Hazel, S. Izod and R. Muirhead

Location: Douglas Daly Research Farm

Objective:

To measure the relative growth, reproductive performance and carcass characteristics of the progeny of some tropically adapted multi-breed crossbred bulls mated to Brahman cows, compared with the progeny of Brahman bulls mated to Brahman cows.

Background:

Multi-breed composites retain larger amounts of heterosis (hybrid vigour) in future generations than do the old style two-breed animals such as Droughtmasters, Brafords and Charbrays. They also combine the good points of the more different cattle types. Most of the large cattle companies such as Napco, AA Company and Stanbroke are shifting to multi-breed composites.

Method:

A composite of 56.3% Brahman, 12.5% Africander, 12.5% Tuli, 6.3% Shorthorn, 6.3% Hereford and 6.3% Charolais is being compared with the Brahman at Douglas Daly Research Farm. This cross gives a mix that is 81% tropically adapted and 19% unadapted *Bos taurus* and can be expected to retain about 64% of heterosis in the second generation onwards. They were created by crossing Brahman cows to half Belmont Red, quarter Tuli and quarter Charbray bulls, obtained from Geoff Maynard's Mt Eugene stud in Queensland.

Results:

The first drop of calves are now yearlings and the initial results look fairly promising. At birth the composites were 0.7 kg lighter (26.8 vs 27.5 kg) than the Brahmans. In November 2001, in comparison with the Brahmans, the first generation composite bulls were on average 16 kg heavier (240 vs 224 kg), had testicles 3.5 cm larger (26.3 vs 22.8 cm) and had 22.5% (five times) more normal sperm (28.1 vs 5.6%).

More composite heifers (79.7%) were heavy enough to join as yearlings, at over 220 kg, than the Brahmans (58.5%). The composite pregnancy rate was 63% compared with 20% for the Brahmans. Overall, 50% of the composites and 11% of the Brahmans were pregnant.

If the whole weight advantage of the crossbred calves is due to heterosis and the second generation cross retains 64% of heterosis as predicted, the combination of fertility and weight advantage will be as follows. When calves are usually marketed at 300 kg live-weight at $1.50/kg, each two year-old composite heifer will produce an extra $183/head in turnoff progeny than the Brahmans. This is a significant increase in profitability.

The second drop of calves are now weaners and the first of the second generation calves from the yearling mating are due in September 2002. This trial has also been extended to the Victoria River Research Station at Kidman Springs. The initial group of Maynard bulls are now at Jindare, a commercial property in the Top End. Consequently, results on the performance of this cross under more extensive conditions will be available soon.

SUBPROGRAM: Farming Systems

PROJECT: Sesame Industry Development

Project Officers: **M. Bennett, R. Sunnerdale and G. Routley**

Location: Katherine Research Station

Objective:

To identify and develop new sesame genotypes suitable for northern New South Wales, central Queensland and northern Australia.

Background:

As a result of the release of cultivar Edith potential yields of high quality seed have been increased by 10%. However, Edith does not have capsule characteristics that minimise seed loss as the crop matures and capsules dehisce. A breeding program was established to transfer the strong seed attachment from Hnani 25/160 to Edith in 1993. Five lines were identified in 1997 as having strong seed attachment. A further five lines were identified in 1998. These lines presented a range of phenotypes, early, mid and late maturing, suitable for northern NSW, central Qld and northern Australia, respectively. Self-pollinated seed of each line was produced, grown and the best individual plant selections identified. Commencing in 1997-98, experiments were undertaken to identify and develop new superior sesame genotypes for the sesame growing regions of Australia. It is anticipated these experiments will be completed in 2003-04. Successful application for Plant Breeders' Rights will take a further two years.

Method:

This wet season two replicated experiments evaluated 18 selections identified for three growing regions. During the season various plant characteristics were measured. Characters were then scored on a scale 0 to 10. Various characters were given weighting according to their importance. A total score for the characters measured were determined. Selections with the highest score and similar physiological maturity (PM) were identified for further evaluation. The remaining selections were discarded.

Progress Report
The superior selections identified this season are presented in Table 1. These selections plus four newly "promoted" selections identified suitable for northern Australia will be evaluated next year with the three best in each maturity group proceeding to the final year of evaluation. Selection evaluation in the final two years will be at three sites, Katherine (NT), Biloela (Qld) and Trangie? (NSW).

Table 1. Superior sesame selections identified at KRS in 2001/2002

	Potential location for commercial development		
	northern NSW[1]	central QLD[2]	northern Australia[3]
Selections	E97W:15/3	E9817:26	E9817:29
	E97W:65g	E9717:28	E9817:61
	E98W1:31	E9717:40	E9817:64

[1] PM = < 1050 day degrees (early maturing)
[2] PM = 1050 – 1250 day degrees (mid maturing)
[3] PM = >1250 day degrees (late maturing)

PROGRAM: Meat and Livestock

1. Beef Cattle Production and Marketing

SUBPROGRAM: Improving Breeding Herd Efficiency

PROJECT: AE as a Management Tool

Project Officer: P. Ridley

Location: Berrimah Research Farm

Objective:

To provide an easy-to use, scientifically plausible adult equivalent (AE) system for use in the NT for the calculation of safe carrying capacities and stocking rates, for cattle of specified weight and performance.

Background:

Emerging estimated safe carrying capacity principles postulate an upper limit to the percentage of each year's pasture growth that may be sustainably removed by grazing.

If the digestible dry matter (%) in the feed is known (or can be plausibly estimated), Moir's (1961) equation relating digestible energy content (Y = Calories/g) to percentage dry matter digestibility (x) can be used to convert this estimate into megajoules of digestible energy.

$Y = 0.046x – 0.158$ $r^2 = 0.98$ $x = 30\text{-}83\%$

Dividing this value by 0.81 (Corbett et al. 1990) converts it to Megajoules of metabolisable energy/kg dry matter (MJME/kg DM).

Standard feed tables such as those provided by MAFF (1984) or NRC (1996) can then be used to calculate the MJME required to support any specified level of cattle performance (e.g. annual growth of steers of known initial weight).

If the annual amount of pasture growth is known and the percentage that can be sustainably removed is specified, it is then possible to:

Calculate the MJME/year/unit area that can be sustainably removed from a paddock (i.e. the sustainable grazing pressure).

Calculate the number of cattle (of specified weight and performance) per unit area that will consume the amount of pasture that may be sustainably removed (i.e. the sustainable stocking rate).

The MJME/kg DM (Minson's M/D) of pasture intake (as derived from Moir's 1961 equation) provides a basis for converting these two calculated values to the amount of pasture (kg) that can be removed per unit area and the of pasture intake kg/head/year.

Method:

The British metabolisable energy (ME) system (MAFF, 1984) was (arduously!) used to estimate the ME requirements (ME_T) of medium mature sized pen-fed *Bos taurus* cattle.

Corrections for the energy costs of grazing (EGRAZE) and *Bos indicus* content on maintenance ME (ME_M) as recommended by Corbett et al. (1990) were applied to these values.

These corrected values were then compared with the corresponding values (also arduously!) calculated, using the computer disc provided by the American equivalent of the British system (NRC, 1996), and were found to be in very good agreement.

The MAFF (1984) equations were then used to estimate MJME/year requirements (y) for a wide range of cattle performance (e.g. a wide range of initial weight (x_1) and annual gain (x_2) over 12 months in the growing phase). Because the MAFF (1984) equations were all linear it was possible to subject these data arrays to multiple regression analysis with no loss in accuracy in calculating MJME/year (i.e. r^2 = unity).

This provided a far simpler process for calculating MJME/unit time than using the arduous processes described in MAFF, 1984 or NRC, 1996, and the same multiple regression process was used to derive equations for *Bos taurus* cattle.

One AE of feed is taken to be the ME required to maintain a 455 kg Brahman steer grazing native pasture for one year (21.8×10^3 MJME/yr).

Results:

The equations to predict the AE requirements of young growing stock in the dry season (AE_D) wet season (AE_W) and over the whole year (AE_T) where x_1 = initial weight and x_2 = annual gain, for *Bos indicus* (Y_1) and *Bos taurus* (Y_2) are:

AE_D	*Bos indicus*	$Y_1 = 0.0010\ x_1 + 0.097$
	Bos taurus	$Y_2 = 0.0011\ x_1 + 0.108$
AE_W	*Bos indicus*	$Y_1 = 0.0011\ x_1 + 0.0013\ x_2 + 0.054$
	Bos taurus	$Y_2 = 0.0012\ x_1 + 0.0014\ x_2 + 0.067$
AE_T	*Bos indicus*	$Y_1 = 0.0021\ x_1 + 0.0013\ x_2 + 0.152$
	Bos taurus	$Y_2 = 0.0024\ x_1 + 0.0014\ x_2 + 0.176$

The AE/head/year prediction equations for adult breeders where x_1 = cow weight, x_2 = weaning percentage and x_3 = weaning weight for *Bos indicus* (Y_1) and *Bos indicus* (Y_2) are:

$Y_1 = 0.0021\ x_1 + 0.0050\ x_2 + 0.0013\ x_3 – 0.168$
$Y_2 = 0.0023\ x_1 + 0.0048\ x_2 + 0.0017\ x_3 – 0.126$

For the purpose of deriving two-way ready-reckoner tables for adult breeders it was possible to drop the weaning weight variable with very little loss of accuracy (i.e. $r^2 = 0.98$). This was due to the strong positive correlation between weaning % and weaning weight. The two equations to provide the values in the adult breeder tables became:

$Y_1 = 0.0026\ x_1 + 0.0060\ x_2 – 0.194$
$Y_2 = 0.0029\ x_1 + 0.0061\ x_2 – 0.161$

The AE/head/year required by *Bos indicus* in the three years of the replacement breeder phase (assuming mating for first calving at a nominal age of three years) was estimated as:

Year	Initial kg	Gain kg	Cow AE	Preg AE	NL AE	Calf AE	AE/head/ year
1	200	110	0.72	-	-	-	0.72
2	310	100	0.93	-	-	-	0.93
3	410	15	1.03	0.09	0.08	0.26	1.46

These values were derived from the young cattle and equations above and values in MAFF (1984) for pregnancy, growth of a 150 kg weaner and nett lactation (NL i.e. the ME that is required to produce milk but is not recaptured by the calf).

The corresponding values for the *Bos taurus* replacement breeder phase are:

Year 1 0.81 AE/head/year
Year 2 1.06 AE/head/year
Year 3 1.64 AE/head/year

Output
The full details of the derivation of the equations reported here will be provided in a Technical Bulletin to be published in 2002/2003.

PROJECT: Breeding Herd Efficiency of Alternative Breeder Genotypes

Project Officers: **M. Cobiac and K. McCosker**

Location: Victioria River Research Station (VRRS), Central Victoria River District

Objectives:

To compare the breeding herd efficiency of alternative cow genotypes (Droughtmaster, Brahman, and F1 – ½ Charolais x ½ Brahman) under extensive conditions.

To produce progeny (Brahman, Droughtmaster and ¾ Brahman x ¼ Charolais) that are tested for growth and their ability to meet future market specifications.

Project Status: Field work was completed, with data analysis continuing. The extension of this project is the proposed project entitled *Charolais/Brahman Criss-Cross Herd*.

Background:

In late 1995, 130 Droughtmaster cattle were obtained from VRRS, while 260 high grade Brahmans and 130 first cross (F_1) Brahman x Charolais cows were purchased from a number of properties in Queensland and Newcastle Waters, respectively. The Droughtmasters represent a stable 2-breed (*B. indicus* and British *B. taurus*) composite, while also providing a connection to the previous breeder work conducted at VRRS. The Brahman herd represented the majority of the herds in the district.

To combat the problem of over-fattening in SE Asian feedlots experienced by district cattle in the early 1990s, later maturing genes were introduced into the herd, using F_1 Brahman x Charolais (½ *B. indicus*, ½ European *B. taurus*) cattle. The ½ European cattle have always been considered as extreme for the tropical environment, however when crossed back to Brahman, the progeny have shown to contain a high degree of tropical adaptation while having some later maturing characteristics. These ¼ Charolais progeny were produced from two sources: the progeny of F_1 (Charolais x Brahman) cows joined to Brahman bulls, and of pure Brahman cows joined to F_1 (Charolais x Brahman) bulls. The production of ¼ later maturing (¼

Charolais, ¾ Brahman) progeny was concluded in September 2001. The resultant replacement breeders generated from this trial are currently being used to produce 1/8 and 3/8 Charolais progeny (Figure 1). In the future the breeding herd efficiency of the 1/8 and 3/8 progeny will be evaluated.

All breeder herds were run under the Department's Best Bet Management System, the basics of which can be found in the 1999/2000 and 2000/'2001Technical Annual Reports.

Female Generation	**Brahman Bull**	**F1 Bull**	**Breeder Year**
	X	X	
1	1/2 Char, 1/2 Brah	Brahman	1996-2002
	X	X	
2	1/4 Char, 3/4 Brah	1/4 Char, 3/4 Brah	2002-2006
	X	X	
3	1/8 Char, 7/8 Brah	3/8 Char, 5/8 Brah	2006-2010

Figure 1. The breeding plan of the later maturing herds

Indicator steers were used to measure the plane of nutrition of each breeder paddock. The minimum average live-weight gain was used as the base and the performance of steers in other paddocks was measured against this by the calculation of ratios.

Results:

This phase of breeder research was completed in May 2001. The database collating the results during 1995-2001 has been constructed and checked. Some preliminary results are presented here; however full analysis of the data is yet to be completed.

Indicator steers have been used to estimate the grazing conditions available in each breeder paddock. However, using these results to correct breeding performance is not well understood. No evidence has yet been uncovered that supports the proposition that using the ratios of relative indicator steer performance (Table 2) as simple correction factors to breeder performance has a valid biological basis. This will be investigated further.

Table 1 shows that the Droughtmaster (DM) herd outperforms all the other breeds with a breeding efficiency of 35.7 kg weaner/100 kg breeder. Table 2, however, shows that the grazing conditions, as indicated by the indicator steer weights, of Conkerberry paddock is also most favourable. Table 2 also shows that both Nutwood and Suplejack paddocks have similar grazing conditions. However, in Table 1 a lower breeder efficiency is seen for the Brahman x F_1 genotype, which were grazing in the Suplejack paddock. An explanation for this is that even though they produced similar weaning weights and rates, the F_1 cows had a larger mature size than the Brahman cows and therefore a lower breeding efficiency.

Table 1: Productivity results from the Kidman Springs breeder herds 1997–2001

Genotype	Mature size of cow (kg)	Calf genotype	Weaning weight (kg)	Weaning rate (%)	Breeder efficiency (kg weaner/100 kg breeder)
DM x DM (Conkerberry paddock)	410	Droughtmaster	181	83.9	35.7
Brah x Brah (Box paddock)	400	Brahman	183	75.8	31.3
F_1 x Brah (Nutwood paddock)	400	¼ Charolais, ¾ Brahman	186	80.2	34.3
Brah x F_1 (Suplejack paddock)	460	¼ Charolais, ¾ Brahman	185	82.1	31.6

Table 2. Tabulated results of indicator steer live-weight gains

Paddock	1996/97 (kg)	1997/98 (kg)	1998/99 (kg)	1999/00 (kg)	2000/01 (kg)	Average* (kg)	Ratio
Box	90	120	131	141	143	125	1.02
Conkerberry	118	141	125	123	157	133	1.08
Nutwood	120	121	116	112	143	122	1.00
Supplejack	102	111	122	112	171	123	1.01

*Average for all years does not include 1996/97 as it was not a complete year. Steers were added in October 1996 and removed in May 1997, thus only spending the wet season in the paddock.

The average empty live-weight (corrected for stage of pregnancy) trends of the Droughtmaster and Brahman breeders (i.e. DM x DM, F_1 x Brah, and Brah x Brah) remained relatively constant throughout the trial period, with a slight increase in weight over the last 18 months (Figure 2). The F_1 breeders (Brah x F_1 herd) on the other hand, showed a gradual decrease in live-weight over time until the last 18 months of the trial where a relatively sharp increase in weight was recorded. The reduction in live-weight was displayed over the first few years of the trial to the point where the crossbreds were similar in weight to the other breeds. This weight loss can be attributed to the initial adjustment to a new location at the beginning of the trial, and the harsh dry seasons of 1998 and 1999, the effect of which is more pronounced in these less tropically adapted cattle. Live-weights of all cattle increased during 2000, reflecting the favourable grazing conditions generally. Similar live-weight trends were recorded in the indicator steer groups (Table 2), supporting the conclusion that seasonal conditions (and hence grazing conditions) had a considerable impact on live-weight gain and loss patterns.

Furthermore, the mature size of the F_1 crossbred cows was found to be the largest (460 kg) (Table 1) of all the breeds and therefore, would have the highest energy requirement for maintenance of body condition. Therefore, as a strong correlation between maintenance energy requirement and fat deprivation exists, the crossbred herd is most susceptible to harsh conditions. The Droughtmasters were shown to have a lower mature size (410 kg) than the F_1 crossbreds. The Brahman herds had the lowest mature size of 400 kg. This was calculated under the assumption that mature size is the weight of fully-grown adults with a fat depth at the P8 site on the rump of exactly zero (i.e. fat depth = 0, but before muscle loss occurs).

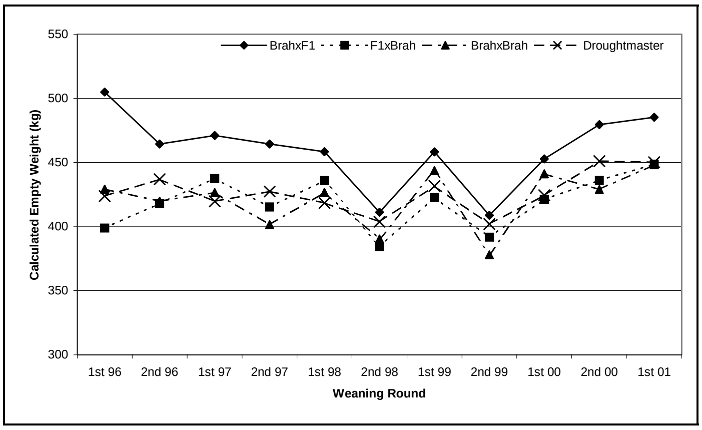

Figure 2. Live-weight of breeders at each muster; adjusted for stage of pregnancy

Over the trial period, breeder deaths were largely associated with calving in poor conditions. Overall, breeder mortalities were 1-2% per annum for the duration of the trial. Droughtmaster was the genotype with the largest number of deaths and unaccounted-for breeders. However, the F_1 cows had a sharp increase in mortality when the conditions were poor, suggesting that this crossbred herd may have been approaching a level where production would have been significantly affected during this trial.

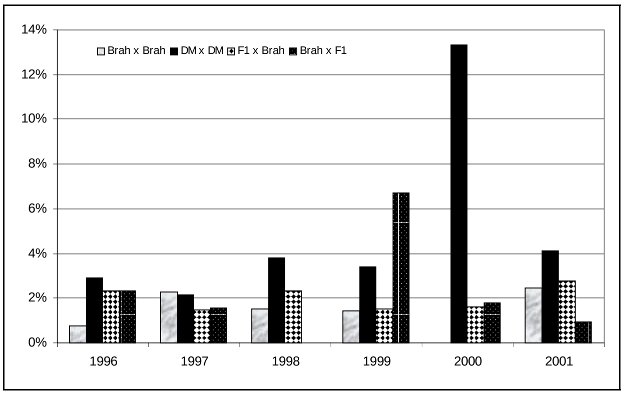

Figure 3. Cow mortality from 1995 to 2001

Conclusions:

Simple crossbreeding or using stabilised crossbreds results in increased breeding herd efficiency over a straight-bred Brahman herd, provided the genotypes are suitably adapted to the region.

Larger cows (e.g. European breeds) have a higher nutritional requirement and thus need to be run at lower stocking rates to achieve a similar total grazing pressure to that of medium sized breeders. This has implications for total herd productivity.

The ‘Best Bet Management System’ results in very good breeder herd productivity regardless of breeder genotype.

PROJECT: Breeding Herd Efficiency

Project Officer: **N. MacDonald**

Location: Rosewood Station

Objectives:

To measure the breeding herd efficiency (kg weaned per 100 kg of cow mated) of commercial cattle on stations throughout the NT.

To collect 20 datasets over a four-year period across the Territory.

Background:

Breeding herd efficiency is being measured across the NT as a benchmark for current commercial practice. In the Katherine region, herds have been monitored at Elsey and Mt Sanford (Poison Creek paddock). The only herd currently being monitored in the Katherine region under this project is Rosewood Station (Cattle Camp).

Activities During 2001-02

As part of the project, 349 breeders were weighed and pregnancy tested on 10/7/01, 1/11/01 and 18/3/02. The main parameter being calculated is calving interval. Data is still being analysed.

PROJECT: Austral Downs Indicator Herd

Project Officers: **A. Doust and D. Savage**

Location: Austral Downs Station, Barkly Tableland

Objective:

To measure breeding herd efficiency (kg calf weaned/100 kg cow mated) in one paddock for three consecutive years at Austral Downs Station, Barkly Tableland by January 2003.

Background:

No published information is available on current levels of breeding herd efficiency in the Barkly region. Such information is required if a measure of change in this variable is to be calculated.

Information from this project will provide some insights into herd dynamics and concurrent:

- Rainfall levels and patterns.
- Pasture and faecal characteristics.
- Cow physiological status.
- Weaning pattern and calf weight distribution.
- Breeder body reserves.

Outcomes/Benefit

1. Identify specific areas of the production cycle where improvements may be possible.

2. Evaluate and compare the financial contribution of the 1st and 2nd round weaners.

3. Estimate the financial benefit of reducing calving spread and therefore increasing/decreasing the percentage of the weaning crop weaned at 1st round.

4. Improve knowledge of pasture condition and the relationship with herd performance and rainfall patterns.

Method:

A herd of approximately 850 Santa Gertrudis breeders are mustered twice yearly to record live-weights, condition scores, pregnancy status and lactation status.

All weaners have their weight, age and sex recorded.

Developments

The following is a summary of the data collected in "Top Paddock" since project commencement.

Trial breeders

	Date of data collection			
	15/4/2000	**7/4/2001**	**4/9/2001**	**4/04/2002**
Number pregnancy tested	641	656	583	451
Average weight (kg)	497	491	469	498
Average condition score*	5.5	6.2	5.7	5.8
Pregnancy tested in-calf cows	258	298	343	152
Non detectable pregnant cows	383	358	240	299
Lactating cows	406	419	263	277
Pregnant and wet cows	82	145	87	31

* Condition scores are a subjective visual gauge to the amount of body (fat) reserves (1 being emaciated and 9 being obese).

The large drop in breeder numbers is a result of cows being culled for age. Replacement heifers have not been included in these results until more data on their performance has been collected.

15/04/2000

- First round 2000 and 82 (12.8%) breeders are wet and pregnant. These breeders have calved and reconceived to hopefully produce a weaner next year. These breeders represent the better performers of the herd.

- 50% of the breeders are wet and this corresponds with the number of calves branded. These calves were returned to their mothers and many will most likely be weaned in the second round.

- Nearly 10% of the breeders are dry and empty and therefore relatively inactive.

- Approximately 27% of breeders are pregnant and dry. Many of these breeders may have weaned a calf earlier and dried off before the first round. These breeders will calve during the dry season. Early dry season calves will be weaners by next round and their mothers are more than likely going to be weaker in body condition than those breeders going to calve just prior to the wet season storms. Cows calving in the early dry season are less likely to conceive at a rate less than those conceiving during and after the wet season.

07/04/2001

- A total of 282 calves were returned to their mothers and 419 breeders were wet, indicating that many cows have produced a weaner, self-weaned and the mother has dried up. The large number of weaners was a result of the earlier than expected wet season and the second round was not completed for this paddock during 2000.

- Interestingly nearly 9% of breeders were dry and empty. However, some of them may have been pregnant early but not detectable.

- Close to 25% of breeders are wet (weaner or calf at foot) and pregnant. These are the breeders attempting to produce a weaner each year and they may be considered the more profitable breeders.

- Around 40% of the breeders are likely to be lactating over the dry season as 282 calves had been returned to their mothers. Considering the exceptional last wet season and the good body of feed that remained, the lactation stress may not have been as severe as during an average year.

- Nearly 47% of the breeders are pregnant but dry and will likely calve over the dry season or early during the wet.

04/09/2001

- Close to 10% of the breeders were dry and empty. As with previous musters there has been a tendency to have around 9-10% of the breeders dry and empty or inactive at this point in time.

- Around 28% of breeders are dry and pregnant now and are most likely to calve over the approaching wet season.

- Close to 47% are lactating and not detectably pregnant. These breeders may take considerably longer to conceive due to lactation anoestrus over the dry season. This may lead to increased time between calving, therefore lowering their productivity.

- 43% of the breeders were recorded as lactating during the dry season.

04/04/02

- First round, 34% of the herd is lactating. This figure could provide some alarm at this time of the year as it could be suggested this period is more optimal to wean a calf and have the breeder conceive. Therefore a larger number of wets could be desirable.

- 12% of the herd are relatively inactive because they are non-lactating and non-pregnant.

- 54% are pregnant but dry. These are likely to calve and produce a calf or weaner by second round. This figure indicates that about half the herd is likely to have the stress of a calf imposed on them over the dry when pasture quality is lower than during the wet season.

Trial calves

	Time of branding			
	15/04/2000	**7/04/2001**	**5/09/2001**	**5/04/2002**
No. of calves returned to mothers	327	282	94	70
No. of calves weighed	321	282	94	70
Ave. weight of calves (kg)	108	106	91	72
No. steers	148	139	40	38
Average weight of steers	107.9	107.1	91.6	75.9
No. heifers	178	143	54	32
Average weight of heifers	108.4	105.2	90.9	68.0
Unknown sex	1	0	0	0

The large number of calves and weaners first round 2001 was a result of a second round not being completed the previous year.

Trial weaners

	Time of weaning			
	6/10/2000	**14/4/2001**	**6/09/2001**	**5/04/2002**
Total animals weaned	18 [1]	345	306	256
Branded males	14	140 [2]	148	37
Branded females	4	0	154	54
Cleanskin males	0	106	21	88
Cleanskin females	0	99	27	77
Average weight (kg) @ weaning	180.9	359.2	191.1	208.1
Average weight gain (kg) @ weaning	48.2	255.9	89.9	172.6
Days between branding and weaning	75	365 [3]	151	212
Average daily growth rate (kg)	0.64 (16)	0.7 (126)	0.6 (250)	0.81 (80)

The number of animals used to calculate these growth rates are shown in brackets.
1: These weaners were weaned from cull cows
2: Only steers were weighed.
3: The long period between branding and weaning was due to an unexpected early wet season start at the end of 2000.

Considering the weaning and branding figures it would appear there is a relatively uniform calving pattern across the year as calf and weaner numbers are similar at both first and second rounds. The large number of calves and weaners during first round 2001 was due to a missed muster because of an early start to the wet season.

	Average growth rate (kg/day) for each weight set at weaning			
Weight set (range) as a calf (kg)	**6/10/2000**	**14/4/2001**	**6/09/2001**	**5/04/2002**
30-55		0.74	0.81	0.82
55-80	2	0.76	0.69	0.83
80-105	0.62	0.71	0.68	0.84
105-130	1.30	0.69	0.54	0.82
130-155	2.25	0.67	0.51	0.64
155-180	1.01	0.59	0.38	0.65
180-205	0.96	0.67	0.23	
205-230	2.73			

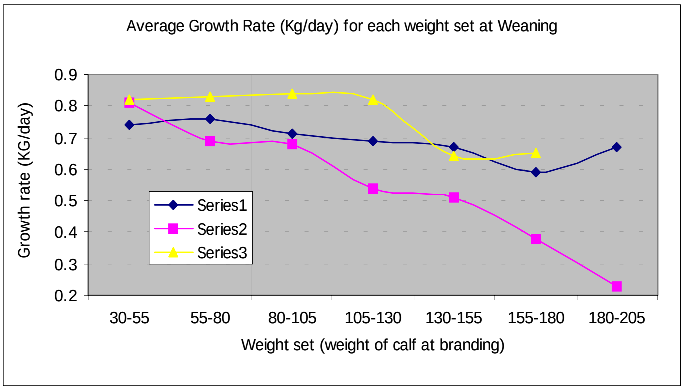

Figure 1. Average growth rate

Pasture and faecal analysis
Pasture analysis results from samples taken from Mitchell and Flinders grass towards the end of 2001 indicate the likelihood of protein and phosphorous deficiency for that particular time of the year. Protein levels ranged from 3.25% to 3.5%. These levels are well below the dietary protein maintenance requirement (7%) suggested as an approximate value for maintenance (Dixon, 2000). Interestingly the condition score of the breeders was relatively the same at both the beginning and end of the year. This may be explained by breeders sourcing browse and may have compensated for the low levels in the Mitchell and Flinders grass.

Phosphorous levels (.06-. 08%) in the diet were again lower than the dietary intake (0.2-0.4%) for maintenance suggested by McLennan and Dixon (2000). The low phosphorous levels coincide with results of other pasture sampling previously conducted in the region.

Results for early 2002 are to be included in the next progress report and will provide an idea of pasture quality directly after the wet season.

Weather analysis
A rain gauge was set-up in the trial paddock late 2001 to collect rainfall records for the coming wet season. At present the rainfall records have not been down-loaded from the rain gauge.

Supplementation
No supplementation has been used to date.

References:

Dixon, R.M. (2000). Mineral nutrition of cattle, *The Northern Nutrition Workshop Training Manual*. Department of Primary Industries, Queensland.

McLennan, S.R. and Dixon, R.M. (2000). Non-protein nitrogen as a supplement for ruminants*, The Northern Nutrition Workshop Training Manual*. Department of Primary Industries, Queensland.

Worrell, M.A., Clanton, D.C. and Calkins, C.R. (1987). Effect of weight at castration on steer performance in the feedlot*. Journal of Animal Science*. Vol 64, Pages 343-347.

PROJECT: Seasonal Calving Study

Project Officers: **A. Doust and D. Savage**

Location: Avon Downs Station, Barkly Tableland

Objectives:

To measure the kilograms of calf weaned per 100 kg of cow mated.

To measure the reproductive performance and some associated variables in a group of breeders at Avon Downs Station, Barkly Tableland.

Background:

There is little information on the reproductive performance of breeders on the Barkly Tableland. This project will serve to produce information on current levels of performance and what effect breeder age, month of conception and body reserves may have on the overall level of kilograms of calf weaned.

The breeder phase of beef production is particularly important in the financial performance of a breeding enterprise because of its low inherent efficiency (kg calf weaned/100 kg of female inventory). Efficiency may be improved by one or more of the following strategies:

- Appropriate supplementation.
- Appropriate stocking rates.
- Rangeland management.
- Heifer selection.
- Breeder management.

Method:

A herd of approximately 850 Santa Gertrudis breeders are mustered twice yearly to record live weights, condition scores, pregnancy status and lactation status.

The weight, age and sex of weaners are noted.

Developments in 2000-2001

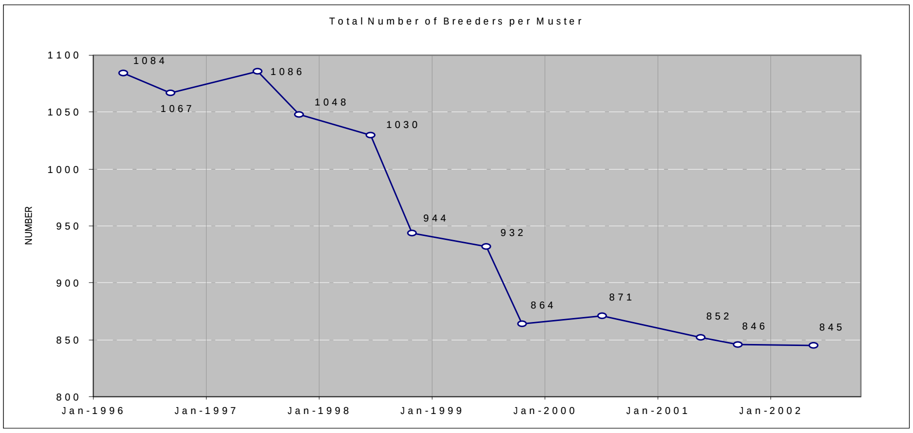

Figure 1. Total number of breeders per muster

The significant drop in breeder numbers to date was due to culling primarily for reproductive failure and other problems such as bottle teats or a broken leg. The other changes in breeder numbers are likely due to breeders being missed during musters, due to downed fences during wet seasons or left in the paddock during a muster if they had a baby calf.

Where breeder numbers began to stabilise (end of 1999) it was due to management not culling breeders for age or reproductive inactivity. No replacements were placed in the paddock.

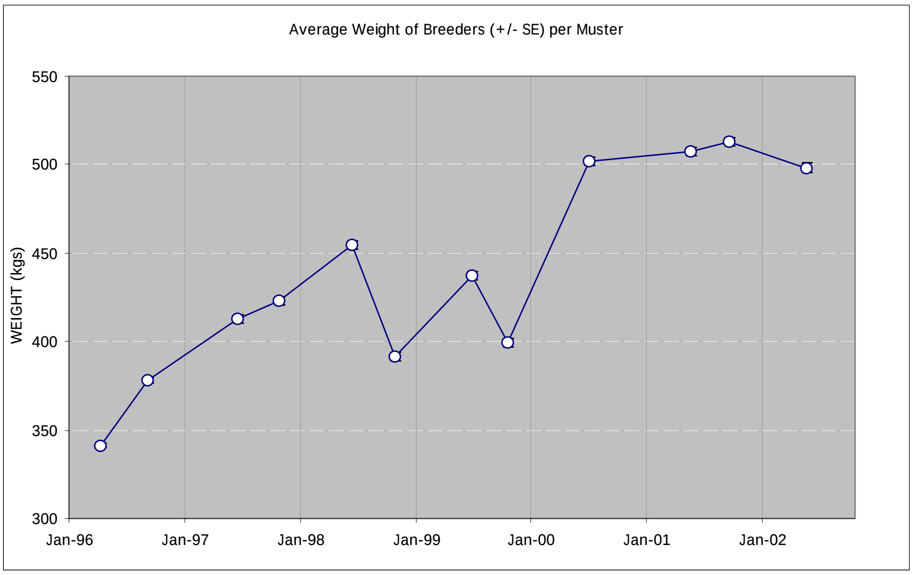

Figure 2. Average weight of breeders

The average weight of the breeders has steadily increased since 1996 and has levelled off from 2000 onwards to settle around the 500 kg point.

The drop in average weight during 1998 was the result of an average season where the breeders lost considerable condition. Cow weight increased in time with the 1998/99 wet season. As 1999 was an average season, cow weight dropped again in the later half of 1999.

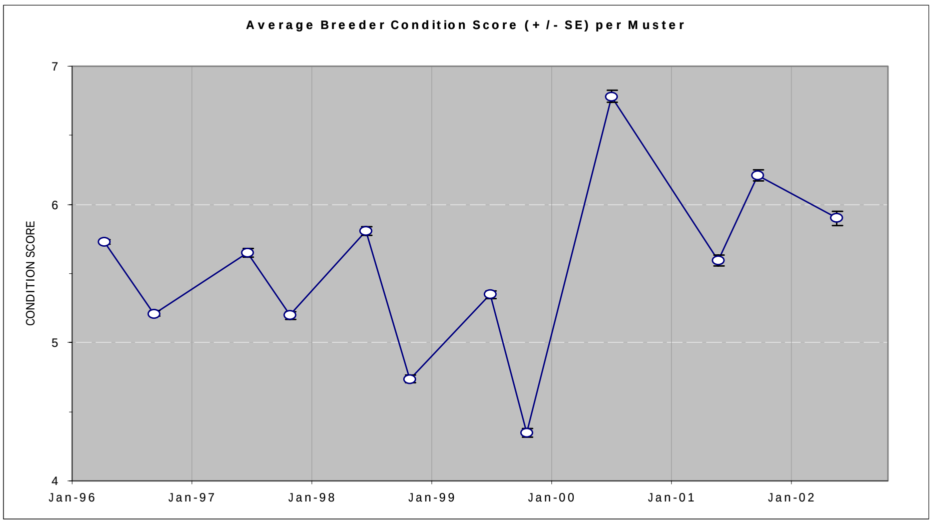

Figure 3. Average breeder condition score

Above average seasons since 2000 have seen cow live-weight increase to finally reach a mature weight of approximately 500 kg.

Figure 3 also illustrates the affect of the season during 1998 and 1999 on cow body condition. Cow body condition fell during the seasonal downturn but rapidly increased from 2000 from where good seasons were being experienced.

If the condition score of 5.5 is accepted as a point at which cows will have enough body reserves to conceive, it appear there are times of the year when cows have less chances of conceiving than those breeders which have sufficient reserves (Figure 3). This tends to suggest that to maximise weaning, breeders need to be ready to conceive when their body reserves are suitable. Figure 3 was developed utilising pregnancy diagnosis results.

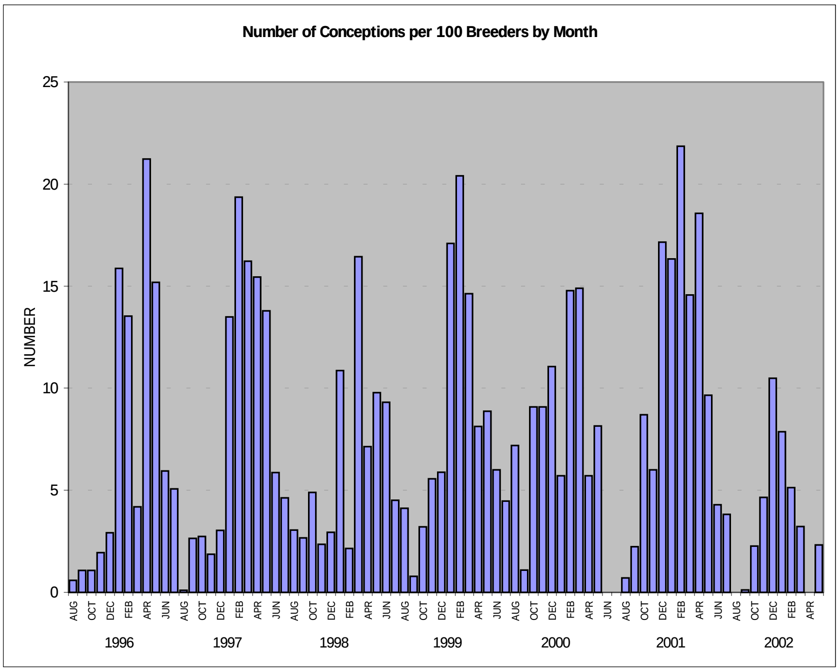

Figure 4. Number of conceptions

Based on diagnosis results, an estimated month of conception could be calculated. Combined results formed the conception pattern in Figure 4. Again an important link can be formed between body condition score from Figure 4 with the conception pattern illustrated above. There is a strong link to suggest that when animal body reserves are adequate, conceptions will increase.

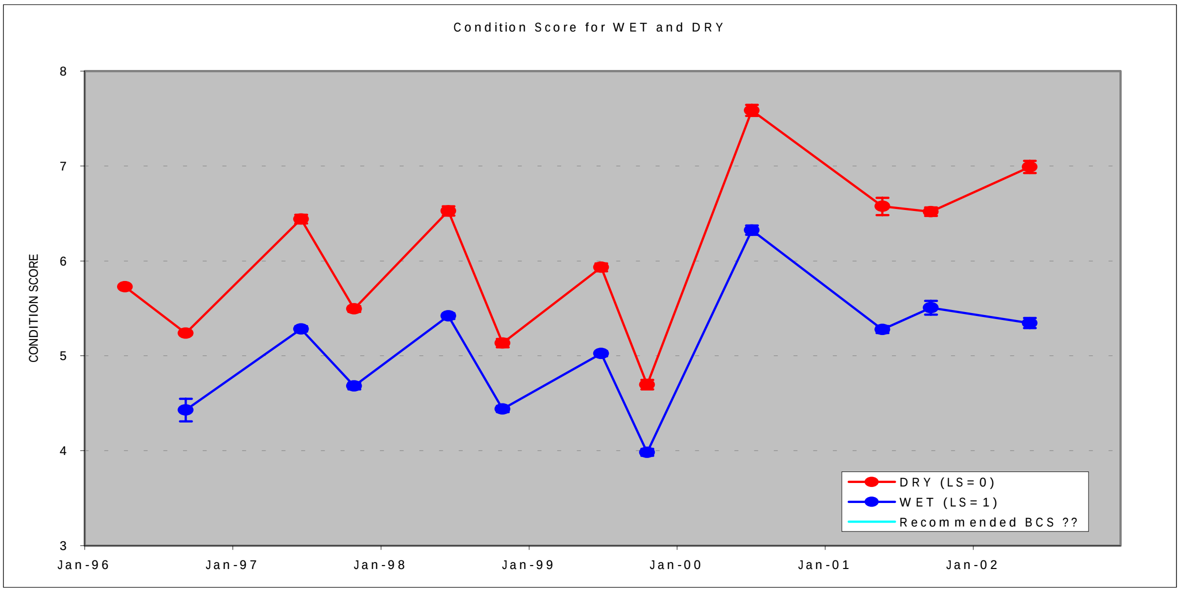

Figure 5. Condition score

To again suggest that a body condition score of 5.5 or above will result in improved conception rates Figure 5 illustrates times of the year in which conception is more likely to be delayed as a result of lactation, thus contributing to lactation anoestrus. Lactating over the dry severely depletes animal body reserves. Average condition scores decrease as the dry season progresses which is consistent with other findings.

The large increases in body condition scores from 2000 to 2001 corresponds to an exceptional wet season and abundant quality feed.

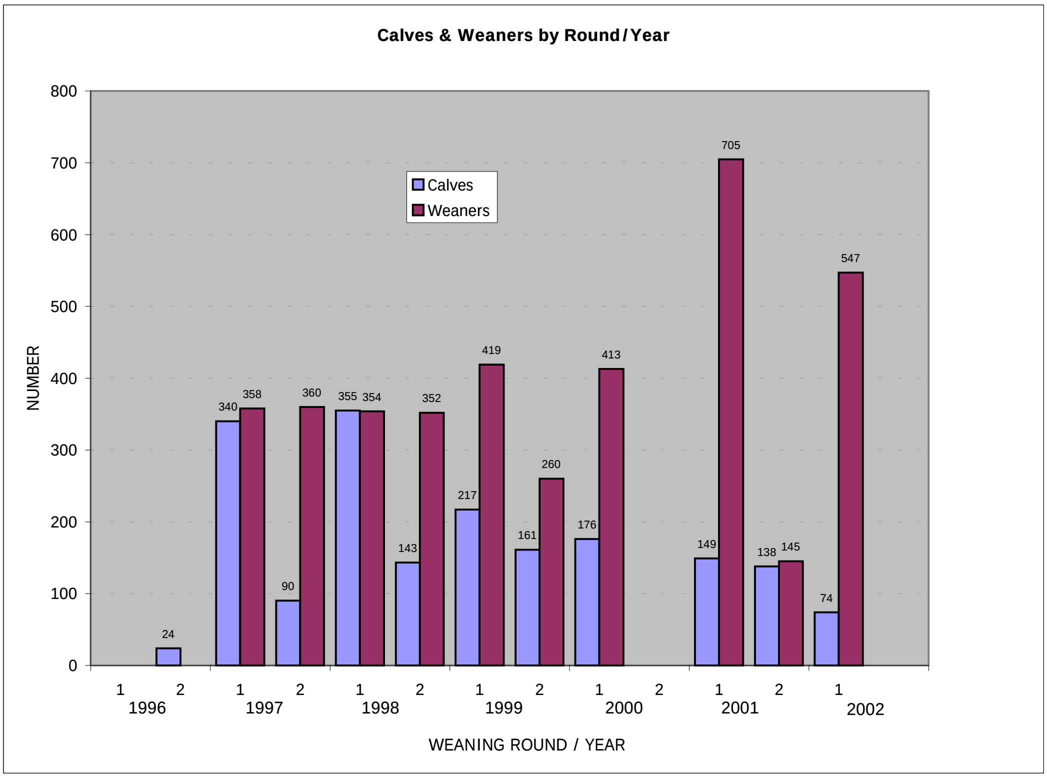

Figure 6. Calves and weaners per year

The first round muster during 2001 yielded a large number of weaners as a weaning round was not conducted late in 2000 due to an early wet season onset.

Weaner numbers each weaning are relatively close up till 2001 illustrating a more even calving pattern across the year.

The large number of weaners during 2002 may be the result of the exceptional year in 2001 thereby enabling cows to conceive and thus produce a weaner early in 2002. The low number of calves returned with breeders in early 2002 will mean fewer breeders will be subject to lactation stress over the dry season.

PROJECT:	**Calibration of Faecal NIRS (Near Infra-Red Reflectance Spectroscopy) for Predicting Diet Quality in Grazing Cattle**
Project Officer:	**J. Akeroyd**
Location:	Brunchilly Station

Objective:

To assist calibration of faecal NIRS technology by collecting diet faecal pairs during pen feeding trials at Brunchilly Station.

Background:

This project is part of a national project coordinated by CSIRO Townsville for the calibration of faecal near infra red spectroscopy (NIRS) across northern Australia. Calibration of faecal NIRS for northern Australia will allow pastoralists to utilise faecal NIRS technology as a support tool to assist with timely decision-making regarding supplementation and to gain a proper understanding of herd performance and pasture quality. Until now faecal NIRS technology had only been calibrated with data from eastern Queensland. To be commercially useful, its calibration is required across the whole of northern Australia.

Results:

Field-work consisting of feeding nine penned animals with three different types of Mitchell grass was conducted in March 2002 as the completion of the field-work. The experiment was conducted over eight days with the cattle being fed harvested pasture for seven days. Pasture species composition was recorded. Paired faecal and diet samples were collected daily. In total 30 faecal samples and 28 forage samples were sent to CSIRO Townsville for analysis.

The project will be completed with the publication of a Technical Bulletin.

PROJECT: Available Soil Phosphorus in the Alice Springs District

Project Officers: **C. Hill, B. Gill and G. Crawford**

Location: Alice Springs District Stations

Objectives:

Sample the soil from DIPE land units under cattle grazing in the Alice Springs sub-districts for available soil P levels.

Categorise the DIPE land units sampled, in terms of the available soil P categories.

Summarise the land units sampled into a broader land classification titled "land types" based on their available soil phosphorous levels for use by pastoralists.

Develop a map of available soil P categories for the Alice Springs district.

Promote the use of cost effective and efficient P supplementation in central Australia by supplying information on available soil P levels during the life of the project.

Produce a booklet for producers titled "A guide to phosphorus supplementation in Central Australia" using the project results.

Background:

Phosphorus (P) deficiency symptoms occur periodically in most cattle herds across Northern Australia, which may cause economic losses estimated around $43/adult equivalent. The profitability of providing P supplements depends on the P level in the diet, the P status of the animal, the class of animal and its physiological state and the supply of other nutrients.

Pasture sampling seems the more logical means of determining P levels, but plant P levels change over time in accordance with seasonal variations, and it is also impossible to exactly know what an animal is actually eating. Faecal and blood samples vary with changes in pasture P levels, and do not give an overall assessment.

Provided soil P is stable over time, and adequate samples are collected, soil analysis can give a good indication of the P status of large areas. These soil P tests measure the ability of the soil to supply P to the soil solution for plant use. The information gained from the soil sampling can be used by pastoralists to plan and implement cost effective P supplementation strategies and aid management decisions on a paddock scale.

Method:

Duplicate grid samples are collected from each land unit according to DIPE land unit maps. These are then analysed for P levels in milligrams per kilogram (mg/kg), and categorised according to these levels of available soil P:

Table 1. Available soil phosphorus

Adequate	Marginal	Deficient
> 8 mg/kg	7 – 8 mg/kg	< 6 mg/kg

Properties are then mapped in terms of available soil P levels.

Summary of Results

Of the 15 pastoral properties in this district with completed DIPE Land unit maps, eight have been mapped in terms of available soil P levels (Narwietooma, Amburla, NewCrown, Erldunda, Curtain Springs (Figure1), Indiana, The Garden (Figure 1) and Orange Creek stations).

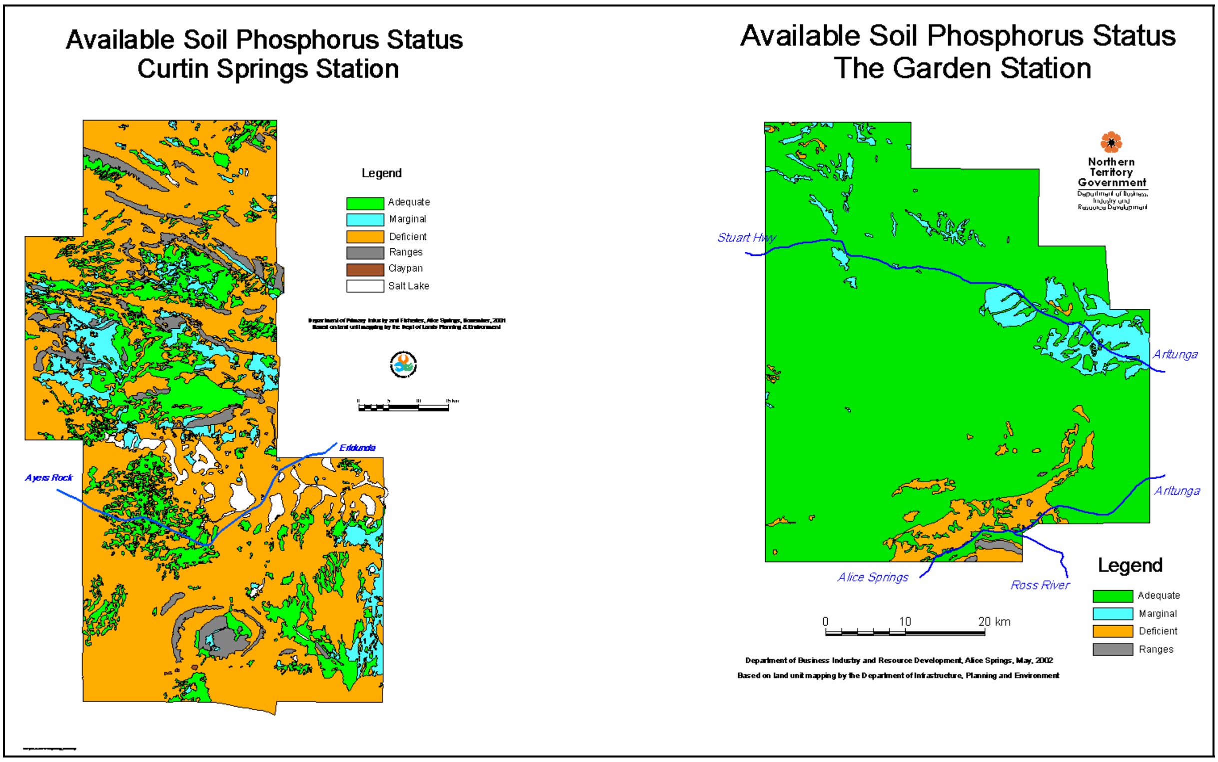

Figure 1. Available soil phosphorus status for Curtin Springs Station and the Garden Station

Figure 1 illustrates the varying nature of soil P availability even within a district. In terms of available soil P levels, the majority of land types on The Garden Station are adequate, whereas Curtin Springs consists of a mosaic of mainly deficient and marginal land types. The practical implications of such differences include the unsuitability of standard supplementation recommendations, and paddock management techniques.

In conjunction with existing pasture and cattle management procedures, these maps can be used to more accurately predict P supplementation requirements on a paddock scale, improving supplementation efficiency. Also, where supplements are not provided, the maps are a useful tool in better managing paddocks through targeting more responsive animals to the better land types (i.e. lactating cows).

Ideally five more properties should be surveyed in order to provide more accurate classifications for land systems ("land types") within areas. A total of approximately 320 samples are required to complete the first two objectives of this project.

Since the closure of the Berrimah soil chemistry laboratory, there are no facilities in the Northern Territory to adequately test for Colwell P (available soil P test). To date only one quote for external analysis has been received. Test soil samples will be sent interstate for analysis and compared with original BARC results for soil P levels of the same samples. The future of this project will depend upon the accuracy and viability of external soil sample analysis.

PROJECT: Near Infra-Red Reflectance Spectroscopy (NIRS) Validation for Central Australia

Project Officers: **C. Hill, District Advisory Staff and AZRI Farm Staff**

Location: Arid Zone Research Institute

Objectives:

Regularly collect faecal and pasture samples from growing cattle for a period of two years.

Provide actual growth rates and faecal samples for Near Infra-red Reflectance Spectroscopy (NIRS) evaluation, enabling calibration equations be developed for central Australia.

Validate the use of NIRS technology to assess pasture digestibility and nitrogen content, investigate dietary selection, and hence aid livestock management.

Present recommendations on the use of faecal NIRS, based on formulated calibration equations and validation results of the technology in central Australian conditions.

Background:

The success of any central Australian cattle enterprise depends largely on the amount and quality (nutritional value) of pastures available for grazing. Knowledge of dietary content and quality of the feed available to cattle is therefore vital to managing their production. Determining dietary quality, and predicting animal performance from that diet, assists in developing efficient nutritional supplementation and grazing management regimes.

Traditional methods of determining digestibility and crude protein content of grazing animal diets (i.e. chemical analysis of pasture samples) are limited by the extensive and varied nature of the pasture lands that make up cattle properties in this district. These factors make the collection of representative samples difficult. Traditional laboratory analyses also have long turn-around times, reducing their effectiveness in helping producers to make management decisions on grazing and nutrition. Faecal NIRS is a more rapid measure of diet quality. Hence, it is a potentially more useful predictor of pasture nutritional content and subsequent animal performance.

Results from NIRS analysis include parameters such as dietary nitrogen content, dry matter intake, digestibility, phosphorus content and C_3/C_4 ratios of diet composition. NIRS has proved to be as accurate as wet chemical methods of determining dietary nitrogen.

Calibration equations to suit central Australian pastures and conditions need to be established before faecal NIRS results can accurately be used in this region as a predictor of pasture quality and animal performance. This project will provide the first locally derived calibrations for NIRS in central Australia and concentrates on one common pasture species. More species will need to be tested.

Method:

The pilot study will be conducted at the Arid Zone Research Institute (AZRI) using departmental cattle as a monitor herd. Faecal and pasture samples are collected, and animal weights are recorded. The pasture is predominantly buffel grass (*Cenchrus ciliaris)*.

The optimal study length is approximately 24 months. Hereford x Brahman females from the existing AZRI sentinel herd, plus additional heifers from the existing AZRI breeder herd, will comprise the sample group for the initial 12 months. After 12 months, these animals will be replaced with Hereford x Brahman weaner steers from the AZRI breeder herd until the end of the study.

Faecal samples are collected fortnightly, alternating between manual rectal collection and paddock collection. Hence, cattle are mustered monthly, and weighed full. Faecal samples are dried, milled and sent to Townsville CSIRO for NIRS analysis. Samples are also retained for faecal nitrogen and dry matter content analysis at AZRI, using a modified Micro-Kjeldahl method. Samples are analysed by both methods to compare the accuracy of NIRS analysis and traditional wet chemical analysis.

Pasture pluck samples are collected monthly. These are dried, milled and sent to NIRS for analysis of nitrogen content and digestibility. Samples are also retained for nitrogen and digestibility analysis at AZRI, using a Micro-Kjeldahl method and pepsin/cellulase method, respectively.

Summary of Results

This study commenced only recently and insufficient results have been collected to present now. They will be reported next year.

PROJECT: Nutrition Laboratory Service

Project Officer: D. Wilson

Location: All NT Districts

Objectives:

Provide a nutrition laboratory service to DBIRD staff and clients from all NT regions.

Provide information required for the prediction of the nutritional status of cattle and the pastures they graze.

Summarise the sampled land units into a broader land classification titled "land types" based on their available soil phosphorous levels for use by pastoralists.

Background:

For over 25 years the laboratory has been analysing pastures and cattle faecal material for nitrogen and phosphorus, dry matter content, and dry matter digestibility. These analyses provide information on the nutritional status of cattle and their pastures, and have been used in many DBIRD projects in predictive and evaluating roles. The majority of samples are received from DBIRD staff from Alice Springs, Tennant Creek and Katherine regions. Laboratory results are placed in the Australian Feeds Information Centre (AFIC) database. The Alice Springs AFIC database has the capacity to provide easy to read and access summaries and reports on individual species of plants, individual NT pastoral properties and NT pastoral regions. The AFIC database now contains over 15,000 records.

With the imminent reduction of services at the Berrimah Analytical Laboratory, the Alice Springs laboratory becomes the principal provider of pasture analysis services for DBIRD. Many projects throughout the NT submit samples to this laboratory for chemical analysis and rely upon its continued operation. Table 1 shows the number of samples analysed in 2001/2002, and Table 2 shows from which region these samples were collected.

Table 1. Samples analysed in the Alice Springs nutrition laboratory in 2001/2002

2001-2002 Samples	% Pepsin / cellulase solubilities	% Crude protein	% Nitrogen	% Phosphorus	% Dry matter
Faecal	-	-	203	145	203
Pasture	708	524	524	267	-
Total	708	524	727	412	203

Table 2. Regional breakdown of samples received for analysis during 2001/2002.

Region	Number of samples
Alice Springs	992
Tennant Creek	419
Katherine	24
Darwin	-
Other	12
Total	**1447**

SUBPROGRAM: Meeting Market Specifications

PROJECT: Summary of Sub Program Results

Project Officers: **P. Ridley, D. LaFontaine and T. Schatz**

Location: Kidman Springs, Mt Sanford Station, Katherine Research Station and Douglas Daly Research Farm

Objective:

To identify the specifications of available markets for live animals/carcases in terms of age, sex, weight, fatness and maturity type and evaluate methods of cost-effectively and sustainably meeting them under a range of environmental conditions.

Background:

The *Meeting Market Specifications* sub-program covers one of the three principal animal production foci for enhancing the contribution of the NT beef industry to the NT economy. It arose as a consequence of major changes in the other two foci (breeding herd efficiency or kg weaner/year/100kg of cow mated and post weaning efficiency or kg gain/unit area grazed/year). These changes followed the reduced stocking rate and provision of fencing induced by the BTEC campaign in the late 1980s and early 1990s and the concurrent adoption of effective N and P supplementation.

In the 1990s the average age of exported feeder cattle at time of embarkation fell by about 1.5 years as a result of improved nutritional management of breeding herds and young growing cattle, with little change in their average weight. Simultaneously there emerged an increasing level of dissatisfaction among SE Asian feedlots in the levels of fatness in these cattle after ‘normal’ periods in the feedlot and/or ‘normal’ weight gains (Beere, *pers comm*).

Value-adding potential (live-weight gain to target fatness) and end-use suitability (the capacity to meet weight and fatness targets) had been significantly and unfavourably altered.

In response to this emerging problem, the sub-program *Meeting Market Specifications* was created nearly a decade ago along with the Kidman genotype comparison.

Aims

The Kidman genotype comparison:

- to detect if there were important differences in breeding herd efficiency between adult breeders of three cow genotypes of different mature size, mated to provide three alternative weaner genotypes also varying in mature size;
- to provide breeding herd efficiency data on a cow genotype of larger mature size than would occur in a potential future cris-cross cross breeding system to meet market requirements;
- to supply weaners of specific mature-size genotypes for post weaning efficiency, value-adding potential and end-use suitability evaluation in the *Meeting Market Specifications* sub-program.

Meeting Market Specifications:

- to quantify *in the environment of production* the effect of a number of factors known to affect post weaning efficiency;
- to quantify the cause of dissatisfaction of a significant and increasing number SE Asian feedlots with over-fatness in carcases from northern Australian feeder cattle when they were fed to ‘normal’ target weights or for ‘normal’ feeding periods;
- to provide practical methods for assessing the mature size of individual Brahman herds and to predict the age that their bull, steer or heifer progeny would have to be to meet given weight *and* fatness specifications at slaughter.

Method:

The flow chart shows where the Kidman weaners went (KRS, Mt Sanford, DDRF) and the main variables that were investigated (a, b. c, d etc) using both industry and Kidman-bred weaners.

Kidman Genotype Comparison

Weaners:

Brahman

Droughtmaster

¼ Charolais

Meeting Market Specifications

Mt Sanford (Mitchell grass)

(a) effect of genotype (4)
(b) effect of weaning weight
(c) effect of sex (steer *vs* heifer)
(d) effect of grazing management (with or without fire plus pasture saving).

DDRF (buffel with 70 kg super/ha/year)

(a) effect of property of origin(15)
(a) effect of weaning weight
(b) effect of genotype (3)
(c) effect of supplementation
(d) effect of castration
(e) effect of short scrotum steers (?)
(f) effect of genotype (4) x stocking rate (4)
(g) effect of sex (steer *vs* heifer)

KRS feedlot phase

(a) maturity type growth curves for bulls, steers and heifers in Droughtmaster, Brahman and ¼ Charolais cattle;
(b) a new value-based description system to reliably segregate feeder cattle into sets of similar value-adding potential and end-use suitability.

Results:

The more important results and the locations where they were obtained are described in Tables 1 and 2. Table 1 details the effects of the main factors influencing post weaning efficiency (kg gain/unit area grazed/year) on native and improved pasture with the performance of Brahman steers as the base line.

Using the maturity type growth curves established in the KRS feedlot, estimates of value adding potential and end-use suitability are given in Table 2.

Both Tables have alphabetic superscripts on a number of the entries and the reader will find relevant detail about each particular entry in the Explanatory Notes section of this report.

Explanatory notes:

The two Tables contain alphabetic superscripts[A] like this and these are explained below:

A. The stocking rate at which no more than 25% of annual pasture growth is eaten on 70% of years (i.e. estimated safe carrying capacity).

B. Preliminary work in a farmlet study showed that the widely quoted ‘safe’ stocking rate of 1 head/ha was far too low and at least 14% more weaners could be run per ha.

C. Data from weaners from 15 commercial stations showed that growth rate differences in the first post-weaning wet season due to effects of property of origin were negligibly small.

D. Data from unweaned calves.

E. First weaning round Brahman steer weaners of the two weight ranges shown in Table 1 (a) and (b) were compared *at the same initial grazing pressure* (i.e. the same initial weight of weaner per ha). This resulted in the stocking rate of the lighter group increasing from 1.14 head/ha to 1.30 head/ha and a 30% increase in post-weaning efficiency.

F. Results from the first two years of the current stocking rate x genotype experiment at DDRF.

G. The prediction of potential value-adding and end-use suitability was made possible from the data on the performance of feeder cattle from Kidman at Katherine Research Station. The predictions assume a slaughter P8 fat depth of 10-15 mm (i.e. for the Philippines market). Value-adding is based on the weight gain at 1 kg/d, that would be expected in the relevant maturity type before market target fatness was exceeded. End-use suitability is the target market weight range at this fat range. These predictions are derived from maturity-type growth curves (weight/age curves at constant specified P8 fat depth) established in the KRS feedlot.

Table 1. Effects of genotype, weaning weight and stocking rate on post-weaning efficiency

Variable	**Supplemented native pasture (Mitchell grass)**	**Supplemented improved pasture (buffel + 70 kg super/year)**
Stocking rate Annual gain	20 head/km^2 [A] 120 kg/head	1.14 head/ha [B] 160 kg/head
Post weaning efficiency		
(a) Maturity type 100-260 kg (av.180 kg)		
Brahman Steer[C]	2400 kg / km^2/yr	182 kg/ha/yr
Droughtmaster Steer	+5%(+120 kg/km^2/yr)	+ 10%
Brahman Bull	+ 5% [D]	+ 10 %
¼ Charolais Steer	+10%(+240kg/km^2/yr)	+ 10%
¼ Charolais Bull	no data	+ 20%
Brahman Heifer	-10% (- 120 kg/km^2/yr)	- 10%
(b) Weight range[E] 140-180 kg (av. 160 kg)		
Brahman steer	no data	+ 30%
(c) Stocking rate[F]		
1.14 head /ha		182 kg/ha /yr
1.50 head/ha	no data	248 kg/ha/yr (+ 36%)
1.80 head/ha		284 kg/ha/yr (+ 56%)

Table 2. Value-adding[G] and end-use suitability[G]

Steer Genotype	**Pasture type**	**Value-adding[G] (gain to slaughter)**	**End-use[G] (slaughter weight at target fatness)**
Brahman	Native Improved	40-60 kg 10-30 kg	380-400 kg 360-390 kg
¼ Charolais	Native Improved	100-120 kg 70-90 kg	450-490 kg 430-460 kg

Briefly, the main findings of the grow-out phase on improved pasture (buffel at DDRF) showed:

- The differences in weaner performance due to property- of-origin were small and not statistically significant;

- Light-weight weaners (140-180 kg, average 160 kg) *stocked at the same total initial weight per ha*. as average first weaning round weaners (100-260 kg, average 180 kg) can increase post-weaning efficiency by about 30%.

- ¼ Charolais and Droughtmaster steers grew about 10% faster than Brahman steers in one experiment but were not significantly different in a second experiment.

- ¼ Charolais steers and Brahman bulls were consistently leaner than the other three steer genotypes and at turnoff had a value-adding potential of about 80 kg compared with 20 kg in the other three.

- ¼ Charolais steers and Brahman bulls with a potential slaughter weight of 440-460 kg at 10-15 mm of P8 fat, again met both the wet market and the supermarket weight specifications in the Philippines. But at 370-380 kg the other three steer genotypes were at the low end of both the wet market and the supermarket trades.

- Bulls grew about 10% faster than steers resulting in ¼ Charolais bulls growing about 20% faster than the alternative Brahman steer (i.e. 20% higher post-weaning efficiency).

- The short-scrotum treatment made bulls infertile but did not reduce their growth rate.

- Steers generally grew about 10% faster than heifers (i.e.10% higher post-weaning efficiency) with their relative post-weaning efficiencies in the stocking rate x genotype experiment being 226 kg/ha/year vs 202 kg/ha/year.

- *Ad-lib* P supplementation in the wet season provided 30-40 kg extra gain. But the significant responses to *ad lib* N supplementation in the dry season either disappeared in earlier maturing types (e.g. Brahman heifers) or was too small to cover costs in later maturing types (e.g. Charolais males) by the end of the wet season.

- In the first two years of the stocking rate (3) x genotype (4) experiment, increasing stocking rate from 1.14 steers/ha to 1.8 steers/ha only resulted in 4% fall in gain/head (from 164 kg/head to 158 kg/head). Meanwhile post-weaning efficiency increased by 56%,

The main findings of the grow-out phase on native pasture (Mitchell grass at Mt Sanford) showed:

- ¼ Charolais grew about 10% (12-15 kg/yr) more than the Kidman or the Mt Sanford Brahmans with the Droughtmasters intermediate.

- The annual growth of Kidman and Mt Sanford Brahmans was about 120 kg/head/year (relative to identical cattle at DDRF where steers at 1.5 head/ha have grown 165 kg/head/year).

- ¼ Charolais were significantly leaner than the Droughtmasters at turnoff and the Brahmans intermediate.

- **¼** Charolais had 100-120 kg potential value-adding with the other three genotypes having only 40-60 kg potential at the end of their first post-weaning wet season.

- **¼** Charolais had potential slaughter weights at P8 = 10-15 mm, of 450-490 kg with the other three genotypes having only a 380-400 kg expectation. These specifications placed the ¼ Charolais in both the supermarket and wet market trades in the Philippines, while the other three genotypes did not suit most of the wet market range (i.e. 80% of the whole market). Price differences between the two markets are negligibly small.

The work at Katherine Research Station in the feedlot which provided maturity-type growth curves for Brahman and ¼ Charolais, cattle showed:

- ¼ Charolais steers were about 15% larger mature size (15% heavier at the same age and carcase P8 fat depth) than Brahman steers.

- Bulls of these two genotypes were about 15% larger in mature size than the alternative steers.

- ¼ Charolais heifers were of similar mature size to Brahman steers.

- The feedlot owner dissatisfaction in SE Asia with over-fat carcases from northern Australian sourced feeder cattle is almost certainly due to the one to two year reduction in their age at embarkation, during the past decade. Larger later maturing genotypes are the only way to maintain both the substantial productivity gains achieved in the NT from major improvements in commercial nutritional management and provide the value-adding required by SE Asian clients.

- Finally the data from the KRS feedlot has provided a basis for the development of a practical low-cost description system that will enable producers to reliably segregate feeder cattle in to lines of animals of similar value-adding potential and end-use suitability.

Independent of this work, the AustAsia company is in the process of developing a market position of being able to provide feeder cattle of reliable and ultimately specified value-adding potential and end-use suitability. The consultant mediating this mindset and operational transition is using the data and analyses from the *Meeting Market Specifications* results as an important part of his training framework.

As AustAsia and other exporters begin to adopt value-based marketing as a tool to gain a more secure foothold or for increasing their market share in SE Asia and elsewhere, they will find it necessary to resort to offering differential prices to secure the specifications most sought-after by their clients. Just as supply and demand will influence price so will price provide the justification for Katherine region beef producers to adopt the same approach as other animal industries and offer their product in reliable lines for specific feedlot outcomes using the specifications in the description system developed in this sub-program.

Conclusions:

Producing larger (later maturing) cattle is the only way for NT beef producers exporting feeder cattle to SE Asia to maintain the remarkable productivity gains that they have achieved in the past decade and also reliably meet customer expectations for value-adding to meet target market weight and fat specifications.

A self-replacing cris-cross crossbreeding system using first cross Charolais x Brahman bulls and Brahman bulls on alternate generations or contracted turnoff of Brahman bulls in place of the alternative Brahman steers are two effective ways of meeting this challenge.

When the necessary price differentials emerge for feeder cattle with different value-adding potential and end-use specifications, NT export feeder-cattle producers need to be sure that they are placed to meet the market and supply the most cost-effective combination of feeder-cattle specifications identified in this work (maturity-type, age, weight).

SUBPROGRAM: Rangelands

PROJECT: Developing Sustainable Grazing Management Strategies for the Semi-arid Tropics of the Northern Territory

Project Officers: **R. Cowley, R. Dyer, L. Cafe, M. Cobiac and D. Bryce**

Location: Katherine/VRD

Objectives:

To ensure that by 2001, throughout the VRD and Sturt Plateau regions of the Northern Territory:

1. ***90% of pastoral land managers are aware of the importance of sustainable management practices.***

2. ***50% of pastoral leases have partially or completely adopted relevant grazing management practices.***

Background:

The final report is overdue. All subprojects have finished in 2001 except for the Kidman fire trials, which will be implemented for a further six years and the impact of rotational fire on grazing distribution trial, which will collect the last data in October 2002.

Results:

1. Better understanding and management of native pastures in the VRD
Growth parameters for the pasture communities of the VRD developed in this project are now being used in pasture growth models to simulate pasture growth with varying climate, pasture and soil types. This information is now being trialled to estimate sustainable carrying capacities on DBIRD research sites, with the potential for this technology to be extended to the pastoral industry. These outputs will be utilised in as a risk management tool (see below).

2. Economic assessment of grazing management outcomes
A model that simulates the impact of different fire regimes and stocking rates on tree and shrub density, pasture growth, cattle productivity and net benefit, has shown that it is economically beneficial to implement a prescribed fire regime. The economic benefits increase over time. Getting your stocking rate right has a greater economic impact than implementing a fire regime. There is a potential to use this model for further location and user specific economic analyses in the region.

3. Assessment of stocking rates and carrying capacity for pastoral properties
The database-GIS software package developed to assess stocking rates will be further developed in a new CRC funded project. This will integrate the stocking rate calculator and Wingrasp into a risk management tool, which will enable land managers to predict long term, current and forecasted carrying capacities.

4. Practical burning guidelines to manage pasture communities and woody plant populations
Final analysis of the first six years data has been completed. Fire management guidelines have been formulated and promoted. The publication *Savanna Burning*: *understanding and using fire in northern Australia* was published in mid 2002. This publication draws together research from agencies across northern Australia. The fire trials at Kidman will be implemented and monitored at a low level until 2007.

5. The impact of woody vegetation

The effects of trees on native pasture production are now incorporated into the GRASP production model, which has been used to estimate the economic impact of woody thickening and sustainable carrying capacities.

6. Sustainable grazing practices producer demonstration sites
Aerial videography methods of monitoring pastures were not successful. Ground based monitoring of spatial grazing patterns with and without rotational fire, has been successful in demonstrating the use of fire in managing grazing. It has been demonstrated that fire is a useful tool in managing grazing distribution at the paddock scale. Paddocks at Mt Sanford will be monitored until October 2002.

PROJECT: Grazing Regimes to Maintain Biodiversity in the Mitchell Grasslands

Project Officers: **R. Cowley and C. Materne**

Location: Mt Sanford Station, VRD

Objectives:

To determine the impact of stocking rate and distribution of grazing pressure on the biodiversity of flora, invertebrates, small mammals and bird species in the Mitchell grasslands.

To formulate best practice stocking and grazing guidelines for the conservation of biodiversity values.

To improve the knowledge and understanding of land managers about maintenance of biodiversity in production systems.

To facilitate appropriate development to enhance profitability and ensure conservation of biodiversity.

Background:

Cattle grazing influences plant and animal diversity in the Mitchell grasslands and in pasture lands generally, in the Northern Territory. However, land managers still lack critical information about management to maximise the conservation of biodiversity within production systems. This currently constrains the development and implementation of integrated management regimes to enhance regional conservation.

Method:

The impact of livestock grazing pressure on plant and bird biodiversity, both total and spatially throughout the landscape will be assessed on an existing long term research site of 60 km^2 of Mitchell grasslands at Mt Sanford. Information from indicator species of flora and fauna will be used to enhance land manager knowledge, understanding and implementation of management for conservation of biodiversity within sustainable production systems. Four paddocks with utilisation rates ranging from 12 to 45% will be assessed for plant and bird diversity from 2002-2005. Other biota will be assessed opportunistically by NTU students and DIPE.

Results:

Sites were set up and the first data assessment of plant and bird diversity was assessed in April 2002. Ant diversity was assessed by an NTU Masters student in Environmental Science in a subset of the diversity plots. Bird data has been recorded on a database, summarised and analysed as preliminary statistics. Singing bushlarks and Zebra finches were more likely to be found close to water. This is contrary to what Fisher (1999) found in the Mitchell grasslands of northern Australia. Golden headed Cisticolas were more likely to be found in lightly stocked paddocks, while Brown songlarks were more likely to be found in heavily stocked paddocks. This supports previous findings. It is anticipated that patterns may change or emerge with time as treatments begin to have an impact on paddocks. Plant data is yet to be analysed.

Developments

An application for a continuation of funding for 2003-2004 has been made to the NHT.

PROJECT: Mt Sanford Grazing Trial

Project Officers: D. La Fontaine and N. MacDonald

Location: Mt Sanford Station, VRD

Objectives:

To investigate the effects of different pasture utilisation rates on cattle productivity and pasture sustainability.

To provide data for wider application of pasture growth models.

To promote the concept of safe carrying capacity through the use of safe utilisation rates.

Background:

The Mt Sanford project started in 1993 as a demonstration of the effects of different stocking rates, testing stocking rates using between five and 15 breeders per sq km. Data was collected twice a year on cattle performance (breeders and steers) and the condition of the native pastures (biomass, species composition, cover and grazing). The results from 1993-97 were recorded in major reports. By 1997, project activities included the monitoring of neighbouring commercial paddocks and the focus had changed to developing sustainable grazing guidelines. The most notable finding of the project was that excellent cattle production could be combined with higher stocking rates if paddock sizes and distances to water were small enough to allow cattle to graze more evenly.

The period of the project coincided with a remarkable series of good wet seasons. As a way of minimising the effect of season, stocking rates were expressed as utilisation rates (percentage of annual pasture growth eaten by cattle). The project has spawned a number of other rangeland projects and has produced data for calibrating the GRASP pasture growth model and estimated safe utilisation rates for carrying capacity estimation on a range of land types.

The project was sponsored by the National Heritage Trust from 1993-2001. From April 2001 – July 2002, the NT Government provided the major funding, assisted by a grant of $35,000 from Meat and Livestock Australia.

Activities during 2001-02

New treatments: In 2001-02, three new treatments were started to complete a response curve with data from the higher end of the scale. At the same time the stocking rate treatments of 7.5, 10, 15, 19, 22.5, 30 per sq km have been replaced by utilisation treatments of 11%, 16%, 22%, 28%, 33% and 44%. The number of animals in the paddock was adjusted after the pasture assessment each May by adding a varying number of spayed cows.

Data collection: As planned, data on cattle was collected in October 2001 and May 2002, and on pasture in October 2001 and April 2002.

Data analysis: Data analysis is up to date. All pasture has been analysed including a substantial backlog, and the cattle data is now on an Access database, which has been checked and corrected.

Field day: A field day was held at Blackgin on 16 August 2001 with the theme "Safely increasing Production in the VRD". It was attended by about 100 people. The main feature was the high level of interest and support by representatives from large pastoral companies.

Supplementation: The new treatments forced the abandonment of the +/- supplement treatments. All cattle are now supplemented and a water medicator was installed this year to service the whole site.

Water supply: To supply the needs of a larger number of cattle on the trial site (currently 500 breeders and 700 growing cattle) a new bore and turkey's nest were installed this year.

Results:

Rainfall: Rainfall over the 2001-02 wet season was estimated at 694 mm from neighbouring stations as the site's automatic weather station broke down over the wet season. This was among the top 25% of wet seasons on record, but it finished very early with no significant rainfall after the end of February.

Pasture: The short heavy wet season proved favourable for annual grass species, notably Queensland blue grass, Flinders grass and annual sorghum. It was less favourable for perennials. There was almost no flowering of Mitchell grass and in some paddocks it was clearly dying back. The effect on cattle was expected to be good weight gains in the wet season, but a rapid fall in the dry season.

Cattle: Overall the weaning rate on the site was 77.4%, but with three new treatments, most of the breeding data this year is meaningless. The three pre-existing treatments returned weaning rates of 78%, 80% and 81%. This is lower than the average from recent years (86%) because of the large number of cows culled for age this year. Steer growth (168, 168, 174, 160, 139 kg/year) averaged 162 kg – well above the long-term average of 150 kg. One of the higher stocked paddocks had significantly lower growth rates.

Developments

Leading on from the 1993-2002 Mt Sanford project, DBIRD and Heytesbury Beef, along with CSIRO and Parks and Wildlife, designed a joint project to test the effects of smaller paddocks and higher stocking rates on a full commercial scale. This project will utilise 400 sq km of Pigeonhole Station as well as the existing Blackgin site and involve 6000 animals. A successful application for funding was made to Meat and Livestock Australia, and the project will start in September 2002.

PROJECT: Grazing Impacts at Exclosed Sites

Project Officer: G. O'Reilly

Location: Alice Springs District

Objective:

Enhanced documentation of existing grazing impacts, and an improved basis for assessing them in the future.

Background:

After the 1960s drought, several long-term cattle exclosures were established around the NT to document range condition and trend over time. Very few remain, but one that is intact is the Spinifex bore exclosure (128 hectares) constructed in 1968 on Mt. Riddock station in sandy open woodland. A detailed study at the site between 1973 and 1978 showed few consistent differences between grazed and exclosed areas (Foran et al. 1982). By the 1990s, obvious pasture composition differences had developed across the exclosure fence and the present study quantifies and documents these differences.

Results:

Pasture attributes important to cattle were estimated three times between 1998 and 2001 at a series of sites inside and outside Spinifex bore exclosure. The treatments were exclosed since 1968, and grazed since about 1954.

The grazed area had consistently higher estimated production and frequency of occurrence of the perennial grass, *Eragrostis eriopoda*. The annual grasses, *Enneapogon polyphyllus* and *Aristida contorta*, were only significant contributors to estimated production in the absence of grazing. Another dominant grass, *Aristida holathera*, was unaffected by grazing (Figure 1).

Various forbs and minor grasses showed significant differences in estimated dry matter production and/or frequency of occurrence when seasonal conditions were favourable for their growth.

There were no differences in the diversity of pasture species between treatments. Pasture species diversity declined after consecutive seasons of above average rainfall (Figure 2). *Eragrostis eriopoda* and *Enneapogon polyphyllus* showed declining production during this period, while *Aristida holathera* continued to increase production.

Limited data is also presented on tree and shrub species, which suggests that the chenopod shrub, *Rhagodia eremaea*, had consistently higher canopy cover inside the exclosure, yet was also the dominant shrub cover in the grazed area (Figure 3). Other species like the fodder and shade tree, supplejack (*Ventilago viminalis*) require further study to assess the impact of grazing on their population ecology.

It was concluded that the relatively short 50-year history of livestock grazing at this site has resulted in a shift in pasture composition, with some deterioration to the balance of useful pasture plants. However, an equally stable vegetation state has developed, which although not as nutritious in good seasons, is inherently more stable, particularly under drought conditions characteristic of the region.

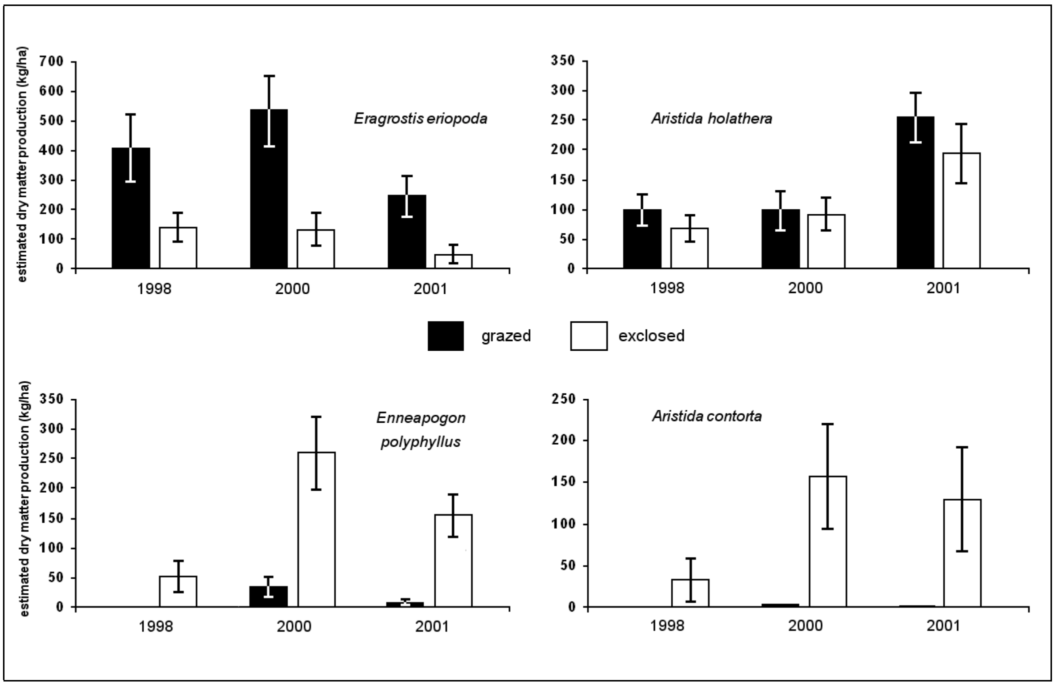

Figure 1. Average estimated dry matter production (kg ha^{-1}) and standard errors of the means for four dominant pasture grasses at Spinifex bore exclosure. Differences between treatment and sampling year shown.

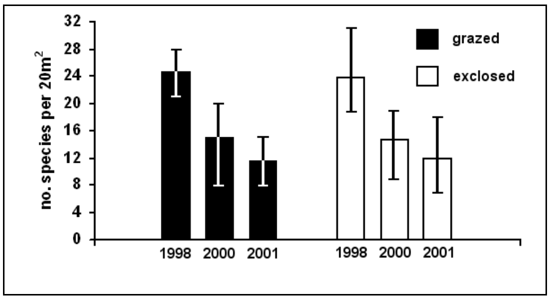

Figure 2. Mean number of pasture species, and range of values recorded in 20 x 20 m^2 samples from each treatment in each sampling year at Spinifex bore cattle exclosure

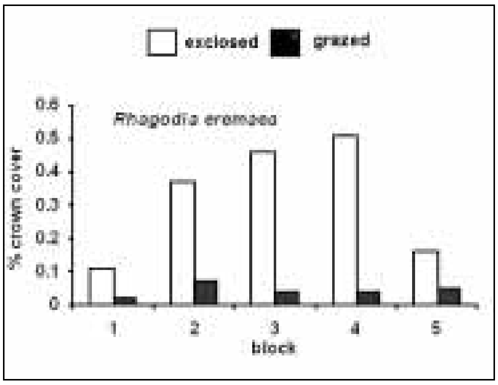

Figure 3. Estimated percentage canopy crown cover of *Rhagodia eremaea* at Spinifex bore exclosure, 1998, as derived by the Bitterlich variable plot method. Percentage canopy cover shown for each of five blocks, with each block being an average value from four sites within each treatment, grazed and exclosed.

PROJECT: Co-grazing Cattle and Camels – Pasture Impacts

Project Officer: **G. O'Reilly**

Location: Waite River Station, Alice Springs District

Objective:

To compare the impacts of co-grazing camels and cattle on key pasture attributes including quantity of important species, botanical composition, and percentage of ground covered by plants and litter.

Background:

The Animal Production Section DBIRD, Alice Springs initiated the project, "Co-grazing of camels and cattle for commercial production" in 1997. The Rangeland Management Section investigated the impact of co-grazing on key ground pasture attributes.

Results:

Pasture quantity, by species, and by functional groupings, as well as botanical composition and percentage ground cover of plants and litter, were estimated at a series of sites within three treatment paddocks. Pasture assessments were undertaken during both drought, and very good seasonal conditions. There were no significant differences ($p<0.05$) between the co-grazed and cattle-only paddocks for pasture quantities including total pasture, annual grasses, perennial grasses, and for Enneapogon spp. (a key grass species for fattening cattle in central Australia).

There was a significantly smaller quantity of forbs available in the co-grazed paddock during all pasture assessments. Co-grazing had no lasting impact on proportion of ground covered by plants and plant litter. It was concluded that co-grazing would cause little impact on grass pasture attributes important for cattle production in central Australia.

Table 1. Camel co-grazing project, Waite River (1998-2000)

Total pasture (all species)

Date	Co-grazed	Cattle only	Control (ungrazed)	*p value*
Month 14	145*	140*	293	*<0.001*
Month 20	32	77	150	*<0.001*
Month 24	403*	460*	511*	*0.038*
Month 27	930*	940*	1487	*<0.001*

All forb species

Month 14	8	24	70	*<0.001*
Month 24	60	115*	141*	*<0.001*
Month 27	162	287*	335*	*<0.001*

Perennial grasses

Month 14	130*	105*	146*	*0.291*
Month 24	193*	208*	178*	*0.881*
Month 27	433*	272*	522*	*0.069*

Annual grasses

Month 14	7*	10*	77	*<0.001*
Month 24	117*	122*	175	*<0.001*
Month 27	335*	381*	630	*<0.001*

***Enneapogon* spp. grasses**

Month 14	1*	3*	44	*<0.001*
Month 24	28*	25*	101	*<0.001*
Month 27	54*	71*	355	*<0.001*

Analysis of variance for averaged yields (kg/ha) of key pasture attributes (*significant if* $p<0.05$; *rep=15, df=42*) at each sampling date are shown above. Treatment averages with the symbol (*) in any one sampling event were not different from each other based on comparison to LSD values.

The results of each aspect of the project, including pasture impacts, were compiled and published by RIRDC.

PROJECT: Fire as a Pastoral Management Tool

Project Officer: G. O'Reilly

Location: Alice Springs district

Objectives:

To gather existing information regarding fire as a pastoral management tool.

To generate new information on the short-term effects of fire on vegetation in more productive range types where woodland thickening affects pastoral productivity.

Background:

Despite the potentially long periods between fires in the arid zone, it is widely acknowledged that prescribed burning is essential for reducing the risk of uncontrolled wild fires during wet cycles and for maintaining diversity in spinifex vegetation. Far less is known about the use of fire in the more productive woodlands of central Australia where several acacia species (*A. aneura, A. kempeana*, and *A. estrophiolata*) have increased, often dramatically, over recent decades.

Results:

Widespread bush fires occurred during 2001 and into 2002 in the Alice Springs district, creating opportunities to observe the effects of fire on target acacia species and their associated pastures. Although some data was collected during the year, an extended dry period since December 2001 to the present has precluded any pasture growth at study sites. Good rains soon after the fires up to and including December 2001 were enough to restore pasture grass quantities (e.g. *Enneapogon polyphyllus*) at some burnt sites. As with burns the previous year, cartwheel burr (*Sclerolaena cornishiana)* was largely eliminated by fire. Hotter patches within fires grew *Cleome viscosa* after rains. Pastures may return to pre-burn compositions as little as six months after fire, or it may take two years or more.

Ironwoods (*Acacia estrophiolata*) over buffel grass have largely survived two fires in two years at this stage, but suffered severe insect attack during the summer months. Cool fires in mulga vegetation may kill 80% of shrubs under 1.5 m in height, but only 20% of shrubs taller than 1.5 m. Witchetty bush (*Acacia kempeana*) has displayed significant basal regrowth, even in seedlings less than a year old. Young mulga has also shown basal regrowth after burning in 2001.

It remains to further observe the recovery of areas burnt during the current good run of seasons and publish the results.

PROJECT: Herd Health and Performance Study - Westside Mount Riddock

Project Officer: **J. Coventry**

Location: Alice Springs

Objectives:

Production of seasonal and property benchmarks of cattle performance, as guides for improved cattle recording and management in the district

Provision of district-specific, technical advice to cattle producers, based on:

- ***normal ranges for biochemical and a haematological values;***
- ***seasonal information on micro-nutrient deficiencies and intestinal parasites;***
- ***correlation of faecal analysis with other indicators of nutritional status; and***
- ***quantification of the effects of seasonal and management variables on breeder cattle performance.***

Background:

Beef cattle production in the Alice Springs district is characterised by large pastoral properties (800 to 11,000 km^2) and large cattle herds (2,000 to 8,000 animals) with low management input. These cattle are mated continuously and grazed extensively on native pastures (grasses, forbs and browse) that grow under variable seasonal conditions on the arid rangelands of central Australia. The extensive nature of the industry together with unpredictable seasonal conditions is a challenge to both cattle management and collection of objective cattle herd data. This in part explains the lack of objective information available on beef cattle herd health, structure, performance and limitations to cattle production in the Alice Springs district.

Method:

Location and data collection
The study is located on Westside Mt Riddock (23^0S, 134.5^0E), 200 km north east of Alice Springs. Pastures in the represented land systems enabled an estimated average stocking rate of 2.6 AE/ km^2. The major features of these land systems are found in up to 60% of the pastoral zone of the Alice Springs district.

The longitudinal study had a five-year collection phase (1991 to 1996) to allow time to record the effects of some season variability and long term management strategies. Collection of data and samples occurred at musters twice per year and field surveys up to four times per year (Table 1).

Cattle
The study was undertaken in a mixed-age Poll Hereford breeder cattle herd, averaging 971 head of breeder cows per muster. Cattle management included year-round phosphorus and urea supplementation; continuous mating (bull rate 5%); annual purchase of herd bulls; culling of breeder cows on temperament, visible physical faults and reproductive performance; biannual musters (March/April, September) with branding and weaning (minimum weaning weight averaged 200 kg over five years).

Table 1. Data and samples collected during the study

Cattle Data and Samples		
	Individual documentation	
	- breeder cows	ear tag number, frame score, age, presence at muster
	- bulls	ear tag number, frame score, age, presence at muster
	Documentation of herd management	tagging, branding, weaning, stocking rate variation, culling, heifer management, supplementation, vaccinations
	Assessment of health and nutritional status	
	- breeder cows	weight, condition score, blood samples, faecal sample
	- bulls	weight, condition score, blood sample, faecal sample
	Assessment of reproductive status	
	- breeder cows	lactation status, pregnancy status
	- bulls	breeding soundness, preputial scrapings
Property Data		
	Feed assessment	qualitative and quantitative recording of an indicator grass "Creek Windmill Grass" (Enteropogon acicularis): % utilisation of grass, stage of greenness, level of recruitment
	Climatic assessment	rainfall recording, temperature recording, seasonal conditions assessment in consultation with rangeland production section
	Supplement usage	number and type of blocks, location of block dispensing
Laboratory Data		
	Assessment of health status	haematological values, blood enzymes and metabolite levels, serum titres for viruses and leptospires, culture of preputial scrapings for 'trich' and 'vibrio', faecal parasite egg counts, bulk botulism cultures
	Assessment of nutritional status	blood micronutrients, faecal %P and N

Results:

Rainfall

The rainfall recordings (annual range: 110 mm to 446 mm) were collated from the nearest consistent recording site (Mount Riddock Station Homestead), approximately 20 km from the centre of the study location. Table 2 summarises the periods of recorded rainfall and 12-month rainfall percentiles (Bureau of Meteorology 2002).

Table 2. Six-month rainfall totals and 12-month rainfall percentiles

	1991	1992	1993	1994	1995	1996
6-month rainfall totals						
Jan. to June	368 mm	206 mm	222 mm	67 mm	310 mm	98 mm
July to December.	36 mm	102 mm	116 mm	43 mm	135 mm	
12-month rainfall percentiles						
Jan. to December.	⇐ 81 ⇒	⇐ 60 ⇒	⇐ 71 ⇒	⇐ 6 ⇒	⇐ 90 ⇒	
July to June	⇐ 44 ⇒	⇐ 69 ⇒	⇐ 29 ⇒	⇐ 73 ⇒	⇐ 50 ⇒	

Breeder cow performance

Review of breeder cow data refines the performance indicators reported in the 1997/98 Technical Annual Report. The five-year average annual performance indicators (calendar year calculations; minimum four years of data; ± standard error) include reproductive rates—pregnancy rate: 83% ± 6%; branding rate: 81% ± 7%; weaning rate: 80% ± 6%.

First- calf heifer re-conception

Review of first-calf heifer data (Table 3) clarifies the conclusions reported in the 1997/98 Technical Annual Report. The average (± standard error) of the three first-calf heifer groups' 12-month re-conception rates have been revised. Compared to the five-year average annual pregnancy rate for the whole breeder herd (83% ± 6%), the average first-calf heifer 12-month re-conception rate is low (52% ± 2%).

Table 3. First-calf heifer group 12-month re-conception rate, Westside Mount Riddock, 1991 to 1994

First-calf heifer group (Number in group)	1989/90 born (42)	1990/91 born (18)	1991/92 born (14)
Re-conception period	1991	1992	1993
12-month re-conception rate *	55%	50%	50%

* no statistically significant difference (p>0.92) (CDCP and WHO 1993)

Figure 1 shows the temporal relationship between recorded monthly rainfall and cumulative re-conception rate for each of the three first-calf heifer groups in a 12-month post-calving period. This supports the conclusion that timing of first-calf heifer re-conception is related to the timing and amount of rainfall. This is consistent with comments about 'effective rainfall' (Perry 1962) and the concentration of spring calving in the Alice Springs district (Shaw et al. 1996). Thus under the influence of the arid climate of the Alice Springs districts, first-calf heifer productivity is potentially variable.

These conclusions are limited by the study's structure—the first-calf heifer sample size was small and entailed only a few strategies for first-calf heifer management in central Australia.

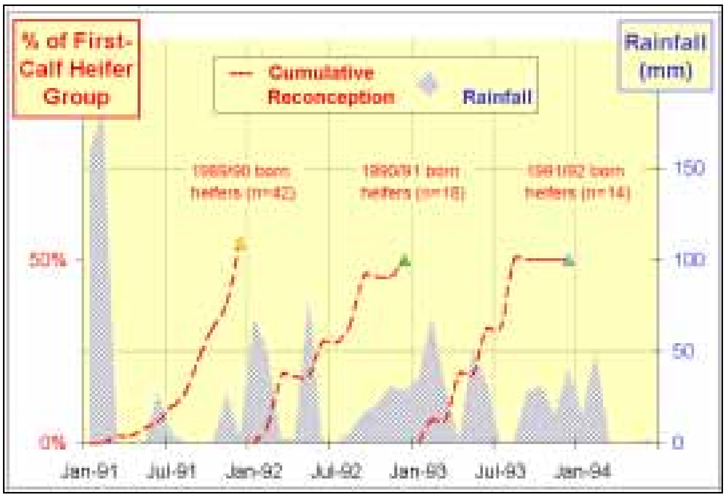

Figure 1. Cumulative first-calf heifer re-conception rate vs. recorded monthly rainfall, Westside Mount Riddock, 1991 to 1994

Practical implications

Breeding female results
The study results have provided objective information on breeder cow reproduction and first-calf heifer re-conception in the Alice Springs district. However, they also highlight the lack of similar information for other aspects of beef cattle production in central Australia, such as the effectiveness of different management strategies for first-calf heifer re-conception, or the influence of first-calf heifer re-conception on life-time breeder performance.

Bull cost for calf production

Calculation of bull-cost of calf production can help assess management in an extensive beef cattle enterprise. Using figures relevant to central Australia we calculated an 'average bull-cost per calf branded' (± standard error) at $36.75 ± $14.77 (Table 4).

Figure 2 models the effect of bull-cost and calves per bull lifetime on bull-cost of calf production and shows the calculated 'average bull-cost per calf branded'. The higher the bull-cost, the more calves that must be sired to achieve a reasonable bull-cost per calf.

The calculated 'average bull-cost per calf branded' lies within a range of bull-cost of calf production figures from other areas. The calculation has a large relative error (40%), reflecting variability in branding rate, effective bull working-lifetime and market prices.

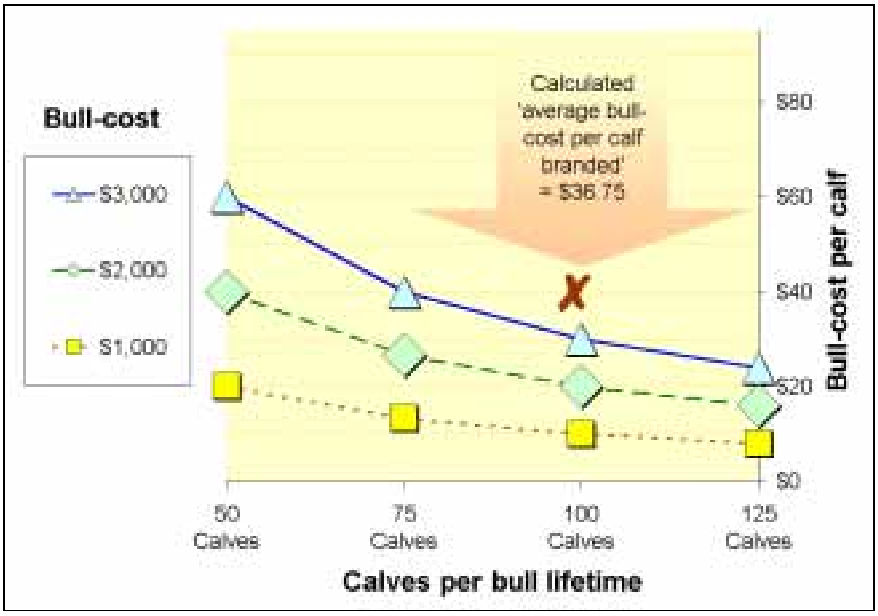

Figure 2. Model of bull-cost per calf

Reduction in bull-cost per calf can be achieved in four ways—reduced cost of bulls, reduced bull to cow ratio, increased bull working-lifetime or increased branding percentage. Specific options for reduction in 'bull-cost' per calf in central Australia include increased culling-for-age and salvage of herd bulls; improved selection and acclimatisation of replacement bulls; and improved reproductive performance of breeder cows—through reduced death rates, optimal stocking rates and cost-effective supplementation.

Table 4. Calculation of 'average bull-cost per calf branded'

Herd parameters and industry-based figures (average plus indeterminate error*)	Source
Annual branding rate (80.8 +/– 7.0 % s.e.)	five-year study Branding rate (~ 'calving rate' in extensive herds) calculated with: **Number of cows mated:** based on breeder cows—individually identified—mustered within a 12-month period plus error values for ear tag loss; **Number of calves branded:** based on freshly branded calves (current muster) plus freshly branded weaners (subsequent muster).
Annual bull rate (5.0 +/– 0.1 % s.e.)	five-year study Bull rate calculated with: **Number of cows mated;** **Number of bulls:** based on herd bulls—individually identified—mustered within a 12-month period.
Annual number of calves branded per bull (16.1 +/– 1.8 calves p.e.)	based on above
Age of bulls culled or found dead (8.7 +/– 0.3 years old s.e.)	five-year study **Age of bulls:** based on purchase records, firebrands, ear-tattoos and incisor teeth.
Age of bulls entering herd (2.5 +/– 0.3 years old b.e.)	five-year study **Age of bulls entering herd**: based on age of bulls purchased plus time to acclimatise.
Effective bull working lifetime (6.2 +/– 0.6 years p.e.)	based on above
Number of calves branded per effective bull working lifetime (100.0 +/– 24.4 calves p.e.)	based on above
Nett bull purchase expenses ($ 2,850 +/– 250 b.e.)	industry figures **Nett bull purchase expenses** … based on Alice Springs livestock agency figures (2001) for bull sale price, freight, feeding, insurance, yarding and treatments.
Nett bull retention expenses per effective bull working lifetime ($ 1,450 +/– 400 s.e.)	survey and finance figures **Nett bull retention expenses:** based on Alice Springs district surveys plus Commonwealth bond rates. (Annual nett bull retention expense = $234 +/– $41 s.e.)
Nett bull salvage value ($ 625 +/– 50 s.e.)	industry figures **Nett bull salvage value:** based on Alice Springs heavyweight-bull live-weight sales (2001) plus commercial quote for cattle freight (2001).
Nett bull acquisition-less-salvage cost ($ 3,675 +/– 700 p.e.)	based on above
Bull-cost per calf branded $ 36.75 +/– 14.77 p.e.	based on above

* s.e. – standard error; b.e. – industry 'best-bet' standard error; p.e. – propagated errors as per Simanek (1996).

Bull testicle assessment

Scrotal Circumference (SC)

Assessment of herd bull SC showed a large range between bulls (30 cm to 50 cm)—high SC (>45 cm) was associated with testicular pathology. Assessment of individual bull SC showed large fluctuations related to age and season. An unacceptable low SC (≤32 cm) was associated with poor seasonal feed conditions.

Analysis of SC records from the optimal bull group (≤ 8-years old, no identified testicular abnormalities) showed that an insignificant difference existed between the group 5-year-average SC (± standard error) for the early- versus late-part of the year (post-summer: 37.3 ± 0.6 cm; post-winter: 38.5 ± 0.2 cm.

Two-sample t-test: p = 0.112) (Genstat 5 1998).

The lowest average SC recorded at muster for the optimal bull group was associated with a recorded 12-month rainfall total that lay within the 30th percentile—the lowest 30% of recorded years.

Testicular Tone (TT)
Assessment showed that 90% of bulls had a TT within an apparent 'normal' range ('high' to 'low') and TT of individual bulls fluctuated within this range.

Summary of the TT records by percentage of four bull-age groups (Figure 3) showed that TT changes with age distribution of TT was significantly different between the younger and the older bull-age groups (Pearson's χ^2 = 9.6 for 3 df; P = 0.022 (Genstat 5 1998).

The TT record summary also showed how culling on gross physical testicular defects and age removed bulls with abnormal TT ('soft', 'hard'). This suggests that increased culling of bulls for age would accelerate removal of bulls with 'soft' TT.

n = 35 n = 114 n = 137 n = 51

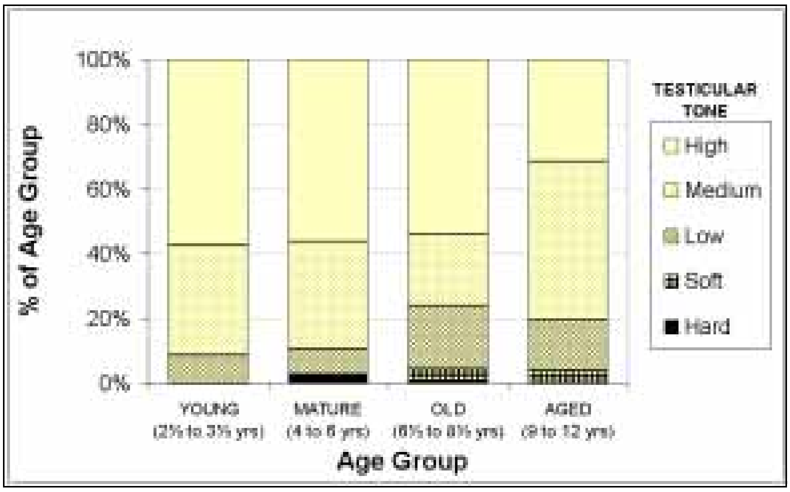

Figure 3. Percentage of testicular tone (TT) records by bull-age group, 1991 to 1996

Study results support conditional use of SC and TT assessments for selection and culling of breeding bulls in an extensively managed beef cattle herd. SC interpretation must take into account variation relative to age, recent nutrition and sexual activity before culling bulls with small testicles. Testicular palpation is best used for detection of abnormal TT (testicular pathology, senile atrophy) in order to cull low-fertility and old bulls.

Practical implications

The study results have provided objective information on herd bulls in the Alice Springs district, through examination of two principles—calculation of an indicator of beef enterprise efficiency (bull-cost of calf production) and effective use of a common bull management technique under extensive conditions (physical assessment of bull testicles).

Conclusions:

The breeding herd results reported have demonstrated benefits from the study, including production of property and enterprise performance indicators (pregnancy rate, branding rate, weaning rate, average bull-cost per calf branded) plus provision of district-specific, technical advice on first–calf heifer re-conception and bull testicle assessment.

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PROJECT: Benefits and Costs of Water Ponding Banks

Project Officers: C. Ballenger and R. Dance

Location: Alice Springs Region

Objective:

To record the potential benefits and associated costs of water ponding banks for increased pastoral production in central Australia.

Background:

Water ponding has been promoted as a means of improving the productivity of some pastoral land in central Australia. While there is anecdotal evidence of the benefits, there has been no economic evaluation

Results:

The second officer appointed to undertake this work resigned in August 2001. Consequently it was decided not to collect any further field data, but as time permits, to write up a final report. This will utilise the limited data which had been collected intermittently since1998. In keeping with the desire to present the economic evaluation of the results in readily understood terms, the economic measure which has been adopted is the elapsed time to recover the cost of construction of the banks.

For the economic analysis it has been estimated that each hectare of ponded pasture will incur a one off bank construction (capital) cost between $100 and $500. Benefit will be derived in either one or two forms. It will be in additional grazing valued at between $56 and $80 per large stock equivalent; or as the cost of hay, which does not need to be purchased for yarded stock or educating weaners if the ponded pasture is used instead, at $0.30/kg. The latter scenario requires that the water ponding be undertaken in a holding paddock adjacent to yards. These two uses for ponded pasture represent quite large differences in value assigned to the additional pasture grown as a consequence of the ponding operation.

Ponding provided no palatable dry matter production benefit at one location on either occasion that it was measured. Otherwise there was a range of additional dry matter available for consumption by stock ranging from 136 kg/ha to 1223 kg/ha, with all but one being less than 650 kg/ha. The least benefit was at locations where native species were planted. The better benefits were associated with the presence of buffel grass.

Changes in plant species composition were recorded as a consequence of ponding. An increase in the density and canopy cover of native shrubs associated with water ponding is demonstrated at one location where it was measured, confirming that this phenomenon can be expected on suitable land types.

There was generally little difference in the number of pasture species found in ponded areas and in unponded control areas, but the nature of the species differed between ponded and unponded areas. These differences appear to be greatest where buffel grass was present, presumably because it tends to dominate other species in the ponded pasture. Characteristic of these differences was the increase of perennial species, and of species palatable to cattle as a consequence of ponding bank construction. These changes might thus be regarded as being beneficial to the stability of the land and for livestock productivity.

Using ponded pasture in place of purchased hay is an economically sound proposition. Utilising ponded pasture for general grazing is a far more doubtful economic proposition. Generally a satisfactory economic return is only demonstrated when bank construction costs are low, combined with a high level of pasture responses. Either economic assessment depends upon the potential benefit from utilising the additional pasture produced. This is more likely in dry years than in more favourable seasons and is arguably more likely where the ponded pasture is used to feed yarded stock, as this requirement is likely to be independent of season. By the end of this reporting period adjustments to the interpretation of the results are being made for differing interpretations of the likely annual frequency of ponding rainfall events.

PROJECT: Green Cover Reporting

Project Officers: R. Dance and C. Allan

Location: Alice Springs

Objective:

To develop and verify seasonal indices of rangeland pasture growth in central Australia

Background:

The most significant cause of variation in the productivity of the grazing industry, both in space and in time, is recognised as being due to variation in the suitability of climatic conditions for plant growth. Any action which people may take to enhance the utility of rangelands for livestock is secondary to unpredictable, unreliable and uncontrollable weather influences. It follows that to make any intelligent interpretation of the effects of management, quantification of seasonal conditions is essential. There is currently no altogether satisfactory means of doing this. The available information is either expensive to collect, qualitative, spatially sparse, or lacks an adequate interpretation model.

The use of satellite based indices of plant growth provides an opportunity to record production on a regional scale at the "grass roots" stage. This project has previously demonstrated the potential of this approach for central Australia. Other States, and the Commonwealth, have also developed expertise in this area, for their own purposes.

Results:

Fortnightly AVHRR data continues to be acquired from the WA Department of Land Administration. It is used qualitatively in near real time within the Department from time to time to clarify the extent of seasonal responses. Images continued to be made available for public use through the Departmental Internet web presence up until 31 December 2001.

Procedures were implemented to apply post launch calibration to the data with a view to improving its consistency between satellite platforms and over time. With favourable seasonal conditions currently being experienced, demand for this data has declined. It is anticipated that further acquisition will be suspended pending a more comprehensive analysis of the data collected so far, and an increase in demand in anticipation of changes in data source. A large quantity of European data has been acquired for comparison purposes.

PROJECT: Alexandria Burning Trial

Project Officers: **C. Materne and J. Akeroyd**

Location: Alexandria Station

Objectives:

To measure the impact of low intensity late wet season fires and high intensity dry season fires on the Mitchell grasslands and woody plant species in Buchanan paddock on Alexandria station.

To demonstrate the application of prescribed burning in the extensively grazed Mitchell grasslands of Buchanan paddock.

This trial consists of two parts:

- An intensively sampled plot trial to identify the response of Mitchell grasslands to burning at two different times of the calendar year, and its effect on the encroaching woody vegetation, and

- A broader paddock-scale trial to demonstrate the use of fire as a pasture management tool

Background:

Traditionally, pastoralists have considered the Mitchell grasslands of the Barkly Tableland as too valuable in terms of cattle feed to burn. Research in other regions suggests that Mitchell grass (*Astrebla* spp.) recovers rapidly after burning and that cattle grazing on burnt pastures usually perform better during the wet season, than cattle grazing unburnt pastures. This along with anecdotal evidence suggesting that woody tree and shrub species are beginning to increase and encroach onto Mitchell grasslands has strengthened the view that there is not enough fire used on the Mitchell Grass Downs of the Barkly Tableland.

The aim of the Alexandria burning trial is to determine the impact of seasonal prescribed fire on increasing native tree and shrub species, pasture composition and quality, and cattle grazing characteristics of the Mitchell grasslands of the Barkly Tableland.

Developments

All plots have been marked and protected by firebreaks. Pre burn data was collected in April 2002, and the first low intensive late wet season burn completed. Next pasture assessments and high intensive late dry season burns are programmed for October 2002.

Implementation of a paddock-scale-burning regime commenced in October 2001. This part of the trial is to demonstrate the use of prescribed burning as a management tool on a paddock scale. Observations indicate the Mitchell grasslands recovered well from the burn after an average rainfall season. Data is being collated on the effect of burning on pasture and cattle diet quality. Further prescribed burning is planned in October 2002.

Duration: 2001 – 2006

SUBPROGRAM: Primelink

PROJECT: Barkly Rangeland Management Course

Project Officers: C. Materne, P. Allsop, D. Savage and A. Doust

Location: Barkly Region

Objectives:

To enable all Barkly pastoralists and their employees to attend a Barkly Rangeland Management Course.

To update and implement courses to improve land management skills of participants.

To stimulate interest of participants in rangeland management and monitoring.

Background:

There has been an enthusiastic response from pastoralists on the Barkly Tableland to the development of a training package based on natural resource management for station staff. The Barkly rangeland management course came to fruition in 1999 and has continued as a series of training days on Barkly pastoral properties.

The project is a joint effort between DBIRD, DIPE and the Natural Heritage Trust and comprises a series of Barkly rangeland management courses available to all cattle stations in the Barkly region. It aims to improve land management skills of employees in the pastoral industry of the region. The objective of the course is to improve the understanding of participants of native pasture dynamics, provide them with training in plant identification and basic monitoring techniques, and stimulate their interest in pasture monitoring when making sustainable land management decisions. The information presented is based on local research and experience, using a selection of DBIRD and DIPE presenters to cover the range of topics.

Developments

Five courses involving six stations and 54 participants were completed during the 2001/2002 period. Participants in the training include the North Australian Pastoral Company (NAPCO), Australian Agricultural Company (AA Company), Stanbroke Pastoral Company and Ucharonidge and Hayfield Stations. In September 2001, the course received a Certificate of Merit in the WESTPAC Landcare Education category during the Northern Territory Landcare Awards. Dates have been set for a further six courses in 2002.

Presentation material and handouts are constantly being developed and modified. A fourth poster on Pasture Monitoring was completed and added to the previous poster series. These posters were produced to complement the course, and were given to each participating station.

All presenters are in the process of obtaining a Certificate 4 in Training and Assessment as part of the process to nationally accredit the course content.

Present NHT funding finishes at the end of 2002 and a final report will be submitted by December 2002. An Interim NHT funding proposal has been submitted for continuation of the courses until December 2003, and its expansion into the Katherine region.

Duration: 1999 – 2002

PROJECT: Breeder Herd Performance Recording

Project Officers: **C. Hill, B. Gill and G. Crawford**

Location: Alice Springs District Stations

Objectives:

Develop a database of reproductive performance records from commercial breeders in the Alice Springs district by taking "snapshots" as opportunities arise.

Model the Alice Springs district herd on the best available information and produce an "average herd" that producers relate to for use as a focal point in discussions on breeder performance.

Extend knowledge of management for improved reproductive performance to Alice Springs district producers emphasising the benefits of recording the performance of individual breeders for the duration of the project.

In conjunction with other pastoral projects, develop management recommendations for producers for improved breeder performance.

Background:

Very little objective production information on beef cattle exists in the Alice Springs district. Other NT regions have quantified production information under research station conditions. Records of breeder performance are difficult to accurately obtain in extensive pastoral situations. For this reason, some in the industry may believe it is not worth the long-term effort to take and keep accurate records.

This project is a modified version of an earlier project that unsuccessfully attempted to monitor performance of small breeder herds on a number of stations. Drought conditions over much of the district during the middle 1990s made it impossible to keep these herds intact.

Using records from the earlier project and records collected during advisory officer activities of pregnancy testing and spaying, this project aims to opportunistically assess breeder performance by recording pregnancy status against several key factors, principally body condition score and lactation status. The information is recorded on an Access database to organise it. The results from the database provide average herd information from the herd to a regional level.

The project serves largely as an extension exercise to encourage producers to think carefully about the performance of their breeding herd and the benefit of monitoring productive performance more closely by keeping better records. Record keeping and monitoring is becoming increasingly valuable as the economics of beef cattle enterprises become tighter.

Results:

Currently there are 6989 entries in the database. Current database results are shown in Table 1. Few records have been obtained this year, chiefly as a result of advisory staff pregnancy-testing fewer animals.

A model of the Alice Springs district herd using the Breeder Herd Performance Recording database has not yet been achieved. It was decided to wait until adequate records (~10,000) existed within the database, rather than just a projected date, before any modelling using these results was prepared.

Table 1. Portion of pregnant cows at each condition score and the total number of animals in each group

Condition score	Percentage of wet cows pregnant	Percentage of dry cows pregnant
1	*	*
2	25%	54%
3	31%	67%
4	48%	75%
5	68%	86%
6	*	*

* Insufficient sample numbers (<20 animals)

PROJECT: AZRI Breeder Herd Crossbreeding Project

Project Officers: **B. Gill, Pastoral and AZRI Staff**

Location: Arid Zone Research Institute (AZRI)

Objective:

Demonstrate the benefits of crossbreeding options that industry could readily adopt to ensure steers are capable of meeting South East Asian and North African live export specifications and North Asian grass and (if lot-fed) grain-fed carcase market specifications by December 2009.

Background:

Historically, beef cattle production in the Alice Springs district has been based on pure-bred British breeds (Hereford, Shorthorn and Angus) supplying steers and bullocks for the southern markets. However, since the expansion of the live export trade to South East Asia during the 1990s, and more recently North Africa and the Middle East, opportunities now exist for central Australian cattle producers to supply a wide range of markets. These additional markets have different animal specifications, including tropical adaptation and weight-for-age requirements. One option for producing animals to suit these markets is crossbreeding to take advantage of hybrid vigour and infuse genes of the Brahman and other tropically adapted breeds.

The potential benefits of hybrid vigour in traits of economic importance in beef cattle are well documented. The amount of hybrid vigour for traits such as fertility and growth rate differs depending on the environment. This project will provide objective local information from a crossbreeding program designed to produce steers that suit a range of markets without compromising female fertility.

Method:

Forty-three sound, proven, purebred Hereford breeders were purchased from a local station in 1997. Herefords have been selected, as they are the most common British breed in the district. These cows have been mated to red Brahman bulls until this year, generating about 80 F_1 (½ Brahman, ½ Hereford) females. Sixty of them will be ready for joining this coming February, the other 20 will be joined the following year. Figure 1 shows the current and proposed mating program for this project.

Mating occurs over a controlled three-month period (February to May) each year and all calves are weaned the following June at about five months of age. If very dry conditions prevail, weaning will occur earlier to prevent excessive decline of body condition in the breeders. Cattle will be supplemented with nitrogen and phosphorus as necessary.

Later, in 2002, the F_1 breeders will be split into two groups: half mated to a red Brahman, and half to a Tuli bull, both of which have been recently purchased. Resulting steer calves will be studied for performance (growth rate) to evaluate the suitability of the various breed combinations to central Australian cattle enterprises.

Results:

The first mating of the two groups (Brahman X F_1 and Tuli X F_1) is to take place in February 2003 with calving beginning in the following November. As such, there are no results to report here.

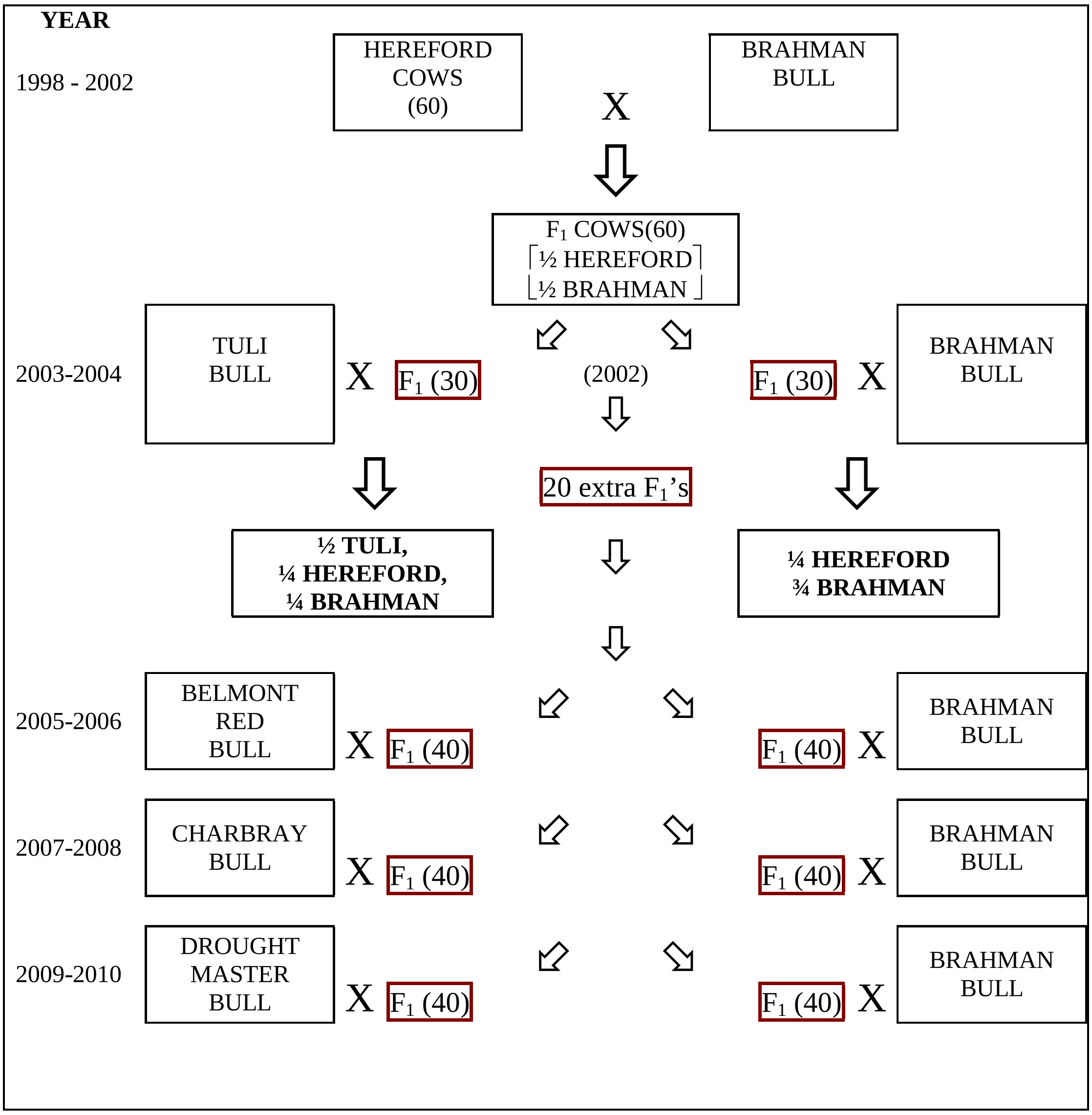

Figure 1. Breeding plan for AZRI breeder herd 1998 – 2010

2. Animal Health

Objective:

To deliver projects to protect and enhance the health and marketability of commercial livestock in the Northern Territory.

This component consists of two sub-programs:

- *Livestock Market Access*
- *Tuberculosis Freedom Assurance Program*

The Livestock Market Access Program of the Pastoral Division delivers projects to protect and enhance the health and marketability of Northern Territory livestock and livestock products.

A key function is providing health certification for consignments of livestock and livestock products produced in the NT, so they comply with the requirements of other Australian States and importing countries.

In order to provide credible health certification, the program monitors the disease status of Northern Territory livestock by investigating disease incidents and conducting planned surveillance activities. Information is collected on the prevalence, incidence and distribution of bacterial and viral animal diseases, plant toxins and other toxic and deficiency states.

The Berrimah Veterinary Laboratories (BVL) play an important role in gathering objective information on disease status of NT livestock.

The TB Freedom Assurance Program (TFAP) was funded for five years from 1998 to 2002. TFAP follows the conclusion of the Brucellosis and Tuberculosis Eradication Campaign (BTEC) at the end of 1997, when Australia was declared a TB free area. The purpose of TFAP is to monitor for five years to confirm the absence of TB and to be able to respond with an eradication program if a TB case is found.

The Division maintains preparedness to deal with outbreaks of animal diseases not normally found in Australia, and carries out surveillance to detect such exotic diseases if and when they enter the country.

Programs are also in place to satisfy consumer demands for animal products that are free from disease and chemical residues. Such programs also help protect the community from zoonoses (diseases transmitted from animals to humans).

The programs depend on a team of professional and dedicated Stock Inspectors, Veterinary Officers and clerical support staff, in close collaboration with BVL staff.

SUBPROGRAM: Livestock Market Access

PROJECT: Animal Welfare Monitoring and Policy

Project Officers: **K. de Witte and Pastoral Division Staff**

Location: NT Wide

Objective:

Participate in the development and implementation of appropriate national welfare standards for animals.

The Animal Welfare Committee (AWC) met for the sixth time. A major business item has been the national review of caged layer hen housing and the revision of the Poultry Model Code of Practice, much of which is now in the implementation phase. The revised Domestic Poultry Code (4th edition) has now been endorsed by the Primary Industries Ministerial Council and will be available to the public. Codes of Practice under revision or being drafted include those on cattle, land transport of sheep, land transport of goats, land transport of poultry, ostriches, deer, horses, and destruction or capture, handling and marketing of feral animals. They are at various stages in the process, and some will be available soon. The issue of a national approach to regulating cosmetic tail docking of dogs has highlighted the lack of an Australian government forum to make decisions on companion and urban animal issues.

The National Consultative Committee on Animal Welfare (NCCAW) to the Federal Minister for Agriculture, Fisheries and Forestry met for the 28th and 29th time in 2001/2002. The following are issues of relevance to the NT:

Position statements
These serve as policy guidelines. The position statement on rodeos was adopted. Topics under discussion include caged birds, tail docking of cattle, calving induction in dairy cattle, bobby calves, destruction of pest animals and a National Code of Practice for zoos. This material is available at www.affa.gov.au/docs/animalplanthealth/animal_welfare/nccaw

National animal welfare strategy (NAWS)
This document has been released for public consultation. There are three goals:

1. To increase public awareness of animal welfare.

2. To ensure the welfare of animals in Australia meets public expectations.

3. To use the nation’s infrastructure effectively for the delivery of animal welfare outcomes.

NCCAW is to assume responsibility for reviews of the NAWS and monitoring of its implementation.

Livestock exports
Overall, the live export industry is performing well, with some useful advances from its R & D and other programs. Australia’s Live Export Standards provide the benchmark for the long distance export of livestock by sea. There were concerns over issues in Egypt and Korea, but these have been largely resolved. The occasional shipping accident has tarnished the general good record of this trade; such incidents are fully investigated with a view to making improvements.

A very large number of other issues that have some relevance to the Territory were discussed including the MLA feedlot shade design review, importation of electro-immobilisers, the national curriculum for training inspectors, harmonisation of legislation, micro-chipping standards, etc.

The department is represented on the NT animal welfare advisory committee. Two Australian model codes of practice for the welfare of animals have been adopted under the *Animal Welfare Act*. They are for "feral livestock animals" and "care and use of animals for scientific purposes". Other codes are under consideration. The "livestock at slaughtering establishments" code has been adopted under the *Meat Industries Act*.

Other issues within the Northern Territory have included the following activities. A public presentation was made to the Northern Cowboys' Association on the NCCAW rodeo position statement, and the animal welfare implications for them. The suitability of the 'ecotrap' was investigated.

All reported animal welfare incidents were investigated. Investigations were undertaken in respect of starving, injured and perishing stock. Poor progress has been made with the national collation of animal use statistics due to software and application problems

The camel industry
The Australian Maritime Safety Authority does not allow camels with less than a 100-mm clearance from the lowest point on live export vessels to be loaded. This requirement makes it difficult for the live trade. A concession on the 100-mm clearance in the entrance hatchway has been recently approved.

Andrew Brown and Peter Seidel met with representatives of Al Hadwa Trading with interests in the camel industry and establishing an abattoir in Alice Springs. They were surprised that camel prices had increased markedly over the past 12 months, and saw a promising future for more intensive management of camels. Details of the latest Parks and Wildlife survey were made available.

PROJECT: Certification

Project Officers: Regional Stock Inspectors and Veterinary Officers

Location: NT Wide

Objectives:

Provide property and animal certification for export, interstate and intrastate movements.

Facilitate interstate movements from the Tick Infected and Tick Protected Areas by providing a service to inspect and/or treat cattle and horses for cattle ticks and for weed seeds.

Prevent the spread of cattle tick from the NT Cattle Tick Restricted Area to tick-free areas within the NT and interstate.

Prevent entry of cattle tick from interstate, particularly acaricide resistant strains from Queensland.

Prevent the entry of Johne's disease and tuberculosis from interstate.

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In consultation with industry and consumers, Government prescribes controls to prevent the spread of animal disease. This was a response to cattle disease plagues common in the 18th and 19th centuries. In recent years there has been increasing industry self-regulation. While market and quality assurance programs have been developed and will continue, there are industry and consumer expectations for governments to protect consumers from health risks and animals from the spread of diseases. This applies within the NT (e.g. for cattle ticks) and for national and international markets (e.g. for bovine tuberculosis and other diseases).

A service is provided to NT producers to facilitate trade by the certification, inspection and treatment of stock, if required. Control programs (e.g. for cattle tick) may also be implemented. Mobile spray plants and chemical are provided for spraying horses for movement.

There is continual review of stock movement controls and area declarations in consultation with State governments and industry associations.

Stock from the tick infected area require a clean treatment (clean inspection and treatment) to pass into or through the NT tick free areas or into the tick free areas of other States. Treatment is by plunge dipping, except for led and tractable horses and show cattle, which may be sprayed in lieu of dipping. The tick free areas in the NT are designated as the Free Zone Protected Area, and the Central Control Zone Protected Area. The tick infected areas are designated the Infected Zone Protected Area, and the Northern Control Zone Protected Area. A map showing these areas can be accessed from the following DBIRD Internet page: http://www.nt.gov.au/dbird/dpif/animals/cattle_ticks.shtml

Cattle moving to Western Australia also require inspection for burrs.

Cattle moving to all States except South Australia require a health certificate. Other stock moving interstate may also require a health certificate.

Certifications are provided to the Australian Quarantine and Inspection Service (AQIS) regarding the disease status of properties and animals to satisfy export protocols. The Animal Health Information System is an associated project for improving the reporting and retrieval of disease data. Planned active surveillance programs complement passive surveillance disease monitoring.

Some export protocols require treatment of animals prior to export. Departmental staff provide this service if authorised private veterinarians are not available.

A total of 288 Property of Origin Health Certifications were provided for the export of cattle from NT properties.

The first tick outbreak in more than 15 years in the tick free area occurred with the discovery of cattle tick on a station in the southern part of the (then) tick free area. An order was imposed to ensure clean inspection and plunge dipping for any cattle transported south. No tick fever has been observed and the owners are aware of all implications. Some tick eradication options are being utilised, but the owners are likely to rely on a series of dry years to eliminate tick populations.

Table 1. Summary of activities for 2001/2002

Cattle inspected and treated for cattle tick from tick areas	
No. of visits	155
No. of head	55,729
Cattle moved interstate from tick free areas	
No. of certificates	334
No. of head	108,309
Cattle inspected for movement to WA	
No. of visits	47
No. of head	34,648
Horses inspected and treated for cattle tick from tick areas	
No. of visits	168
No. of head	1,275
Other stock inspected	
No. of visits	10
No. of head	1,782
Total property visits	380
Cattle inspected at saleyards	
No. of visits	80
No. of head	33,344

PROJECT: Chemical Residues in Animal Products

Project Officer: **A. Brown**

Location: NT Wide

Objectives:

Present chemical residue-free animal products to the consumer, and protect and maintain the NT meat and milk markets.

Provide an advisory service on chemical residue issues to industry, government and the public.

Represent the NT on relevant national committee.

The NT animal industries do not have a chemical residue problem. However, there are ongoing programs to monitor the situation and demonstrate the absence of residues. There are no properties under quarantine.

This program has four components:

1. National residue survey.

2. Beef organochlorines, organophosphates and synthetic pyrethroids residues.

3. Hormonal growth promotants.

4. National antibacterial residue minimisation program.

National residue survey (NRS)
NRS is a random sample survey to monitor residues in Australia’s agricultural food commodities, and has been operating to some extent since the 1960s.

Since 1996 the need for participation in the NRS for domestic consumption as well as for the export market has created an additional cost for small industries.

During 2001/2002, DBIRD signed an agreement with NRS to follow-up trace backs greater than the residue action level, usually maximum residue limit (MRL) and take appropriate action.

Activities
During 2001/2002, 101 samples were collected from NT stock, primarily through abattoirs. There were 65 cattle, 9 buffalo and 15 camel, 9 horse and 3 pig samples analysed with no detection greater than the MRL/maximum permissible concentration (MPC) from an NT property. There were no detections of antimicrobials, organochlorines or organophosphates.

Thirty samples of shark fillets were sampled for NRS. Four samples showed residues of mercury 1.5 times the MPC. Fisheries inspectors investigated the source of the contamination and concluded they were of environmental origin. No further action has been taken, but monitoring will continue.

Beef organochlorines, organophosphates and synthetic pyrethroids
The main issue for the Northern Territory continues to be the interval between the last treatment with cattle tick and buffalo fly treatments and slaughter, to satisfy the limit to MRL in both domestic and export markets.

Advice was provided to all producers in the cattle tick and buffalo fly area on the residue risk and control of cattle ticks and buffalo flies.

Hormonal growth promotants (HGPs)
Many domestic and export markets are sensitive to cattle products derived from animals implanted with HGPs.

A national program to comply with European Union (EU) import requirements was developed in 1993 which satisfied EU reviewers. This program comprised two components - controls on the use of HGPs in the cattle industry, and systems for the recognition of stock which have not been implanted with HGPs. Controls on HGP use are underpinned by the *Control of Hormonal Growth Promotants (Stock Act*) (NT). Two properties are audited for compliance each year. A register of HGP users is maintained in the NT as a requirement of the national HGP control system. Last year, 76 properties in the Northern Territory purchased 169,000 doses of HGPs for use. This is about two-thirds the number of doses purchased in the previous year.

On the 1 December 1999, a new national system for declaration of HGP freedom began which was designed for accrediting properties wishing to specifically supply the EU market. Accredited properties are only to hold cattle not implanted with HGPs, hold appropriate documentation, and adopt the National Livestock Identification Scheme (NLIS). Accredited properties may only purchase cattle from accredited properties and must notify NLIS national database of the individual identification of any stock sold outside the system. This component is now covered under the Federal *Export Control Act*, but is administered by state authorities. There is currently only one NT property that is EU accredited. However there is interest from many others.

NLIS describes use of permanent devices containing electronic transponders from which individual identification can be read electronically. Approved devices may be rumen pellets or ear tags applied at weaning which then will remain with that animal for life.

Three audits were completed during the year as required under the national HGPs audit program (two users, one EU accredited property). NRS reimburses the states for this activity at $380/audit.

During 2001, use of pink tags bearing the words "HGP Free" were allowed to be used as transaction devices to declare cattle HGP free, but were no longer accepted for the purposes of the EU market. Industry requested this system to remain for the purposes of other markets such as Saudi Arabia, Korea and Jordan. AQIS now uses the pink tag together with the appropriately endorsed National Vendor Declaration as the basis for the Non-EU HGP free certification system.

National antibacterial residues minimisation program (NARM)
NARM is a national program to monitor antibiotic and antibacterial contaminants. The national program is now targeted to high-risk areas, which excludes the Northern Territory. Another initiative by AFFA is the targeted antibacterial residues minimisation program. This allows AQIS officers in abattoirs to select high-risk animals for sampling for antibiotic residues.

PROJECT: Crocodile Farming

Project Officers: V. Simlesa and R. Harmata

Location: Darwin and Katherine Regions

Objective:

To provide a regulatory service to crocodile farms in the Northern Territory.

In order to carry out regulatory duties under the *Territory Parks and Wildlife Conservation Act* on crocodile farms in the NT, three DBIRD officers are appointed as honorary conservation officers. In addition, the veterinary officer is authorised to provide certification under the Commonwealth *Export Control Act*.

Regulatory duties include:

- The inspection and certification of export shipments.

- Collation of monthly reports from all NT crocodile farms to Environment Australia through the Department of Infrastructure, Planning and Environment of the NT.

- Regular full audits and/or inventories of all stock on NT crocodile farms to conform to the requirements of the Convention of International Trade in Endangered Species of Fauna and Flora (CITES).

- Issuing of export permits involving farmed crocodile products produced in the NT.

- Regular inspection of NT crocodile abattoirs and the issuing of health certificates to accompany crocodile skins, as required by importing countries.

A disease investigation service is provided to all NT crocodile farms on request.

Activities
DBIRD is responsible for all regulatory duties associated with the crocodile industry in the NT.

Peter Watson, a South African crocodile farmer toured NT crocodile farms with the cooperation of the Queensland Department of Primary Industries (QDPI). He was interested in exchange of information and a possible venue for the establishment of a crocodile farm in the NT.

A Rural Industries Research and Development Corporation and QDPI joint venture to manufacture pellets as a source of feed for crocodiles started testing the product on cooperating NT farms.

DBIRD supplied funding to share the costs of a crocodile immobilisation project run by Wildlife Management International. The project aims to assess the types of drugs and dosage rates necessary for crocodile immobilisation.

A live crocodile display and industry information was presented at the Royal Darwin Show Also, the Technical Officer gave crocodile industry talks to a number of schools as part of school projects.

The Technical Officer for crocodiles also completed a workshop in foot and mouth disease training, and graduated from NT University with a Bachelor of Science degree.

A total of 78 NT movement permits were issued, 31 of which were for export overseas. This is a decrease in the number of permits issued compared with last year. A total of 4,386 crocodile (*Crocodylus porosus)* belly skins were exported overseas. A total of 14 skin shipments were inspected and three health certificates issued. A total of 1,115 crocodile belly skins were sold in the domestic market. A total of 3,753 crocodiles were processed yielding 19,959 kg of flesh. A total of 3,640 live crocodiles were exported domestically.

PROJECT: Disease Surveillance

Project Officers: D. Pinch, Veterinary Officers, and Stock Inspectors

Location: NT Wide

Objectives:

Provide credible disease surveillance information to support the sale of livestock and livestock products.

Investigate the occurrence of diseases in the NT livestock industries.

Participate in national animal health surveillance programs.

There are several areas of activity that contribute to the successful implementation of this project, and they are discussed below. Disease surveillance encompasses:

1. The collection of animal health data during disease investigations initiated by the producer (passive surveillance).

2. Planned surveys to target a specific disease (active surveillance).

3. The provision of NT information as part of national programs to enhance Australia's trading status.

4. A secure and reliable computer system to store and retrieve the data and communication of results to relevant parties.

Johne's disease zoning
The Veterinary Committee introduced formal zoning for bovine and ovine Johne's disease (JD) in Australia on 1 August 1999. There are four zones for both bovine and ovine JD: Free, Protected, Control and Residual. The Northern Territory is a Protected Zone for bovine JD.

In order to maintain Protected Zone status, the Northern Territory is required to fulfil objectives set out in the Standard Definitions and Rules for Bovine JD. This involves surveillance activities and an annual report to Veterinary Committee. The Northern Territory's Protected Zone status was endorsed for another year at Veterinary Committee 11 in October 2001.

During 2001/2002 the Northern Territory conducted surveillance on properties that had imported cattle from Control Zones interstate. This surveillance involves performing a test on blood collected from the imported cattle and up to 100 in-contact cattle. There have been six properties, all in the Alice Springs region, monitored as part of this surveillance during 2001/2002. There has been no evidence of JD through this surveillance.

The active surveillance for JD was demonstrated to be effective in June 2002. Two house cows on two different properties underwent serological testing, as part of surveillance on a dairy herd that was being dispersed. The dairy had imported animals from Control Zones interstate. Both cows had positive reactions to an enzyme-linked immunosorbent assay for JD. The cows underwent post-mortem, and returned positive results for culture of *Mycobacterium avium* subsp. *paratuberculosis*. Histological changes characteristic of JD were not detected, and neither cow had exhibited clinical signs of JD. A trace forward program is now operating for other cattle from the index herd. At the end of June, 11 properties had been issued quarantine orders, pending resolution of their situation.

Movement conditions for livestock in relation to bovine JD changed during the year. Cattle, buffalo, goats, alpaca and llama must not be introduced to the NT from Control Zones for bovine JD unless they are from a Monitored Negative 1 (MN1), or better, status herd established under an officially recognised Market Assurance Program for that particular species.

National animal health information system (NAHIS)
NAHIS is a surveillance program coordinated by Animal Health Australia that has input from the State/NT governments and the Commonwealth government. The NAHIS provides timely and accurate summary information on Australia's animal health status to support trade in animal commodities and meet Australia's international reporting obligations. It also provides information on Australia's capabilities and activities with regard to animal disease surveillance and control.

A quarterly report is provided to NAHIS on NT animal health status, specific testing carried out at Berrimah Veterinary Laboratories and significant animal disease events. Similar reports from all the agriculture/primary industry departments, as well as information from AQIS, NAQS, the National Arbovirus Monitoring Program, the National Residue Survey, the Commonwealth Department of Family Services and Health, and various national reference laboratories are collated.

A quarterly report, *Animal Health Surveillance Quarterly*, is produced and circulated within the NT to various addressees, including livestock industry groups. There is also information about NAHIS on the Animal Health in Australia Internet site at: www.aahc.com.au/nahis/index.htm .

National transmissible spongiform encephalopathy surveillance program (NTSESP)
Australia is presently free of bovine spongiform encephalopathy (BSE) and scrapie. However the Office International des Epizooties (OIE) International Animal Health Code requires that countries claiming to be free of transmissible spongiform encephalopathies (TSEs) have a surveillance system in place to detect BSE and scrapie should they occur. It is important that Australia meets this requirement to assure continued access to export markets. The NTSESP was started in 1998 to address this issue. Animal Health Australia coordinates the program, with State/NT/AQIS coordinators organising activities in their region.

OIE guidelines have been used to determine the necessary surveillance levels. Surveillance involves examining a large range of specimens from cattle (over two years of age) or sheep with signs of nervous system disease. The number of cases that each State/Territory need to examine has been calculated according to their cattle or sheep population.

There should be 24 cattle cases examined from the NT annually (no sheep).

The program operates on the calendar year. The NT achieved 25 submissions from cattle that were negative for BSE in 2001. Twenty-two were sampled in the NT and three were sampled in Queensland. Government veterinary officers, stock inspectors and a private veterinary practitioner collected samples in the NT. Some of the diagnoses for the sampled animals were zamia plant poisoning, bovine ephemeral fever, septicaemia, trauma and pneumonia.

Animal health news - NT (AHNNT)
The quarterly publication of this newsletter by staff in the Berrimah Veterinary Laboratories and the sub-program Livestock Market Access started at the beginning of 1996. It is sent to all registered veterinarians in the NT (and bordering towns in WA and Queensland), stock inspectors, NT livestock industry organisations and other interested people both within and outside the department. The articles from laboratory and field staff in southern and northern regions cover topical animal disease events, animal health surveillance news, information from Berrimah Veterinary Laboratories and other items.

Issues 22 to 25 were produced during 2001/2002, with about 180 copies distributed each quarter. The newsletter is available from the DBIRD website:
(www.nt.gov.au/dbird/dpif/pubcat/newsletters/ahnnt.shtml). Issue 25 (April 2002) was used to survey the readership. Responses indicated that the newsletter was well received, and the articles' content and length appeared to satisfy readers. The design of the front page was updated from Issue 25.

NT animal health information system (ANDI)
ANDI is an accurate and reliable mainframe database for storing animal health information. ANDI is used by both laboratory and field animal health staff for storing and retrieving investigation details and results. Quantitative data from ANDI is used for preparing the NT report to NAHIS and significant disease event information is stored on it

It is used to record and report details and results on all submissions to Berrimah Veterinary Laboratories from a wide variety of clients such as other DBIRD staff in animal production, agriculture, and fisheries, private veterinary clinics and the public.

The Department of Corporate and Information Services is comparing the performance of ANDI with that of the Agriculture Western Australia Client and Resource Information System, and the implementation of SampleManager (a laboratory information management system). The purpose is to determine if they would meet current business requirements for managing veterinary laboratory and fieldwork testing, as currently performed by ANDI. The study started in 2002, and is still under way.

The departmental name and address changes were updated on all ANDI reports by the mainframe services provider. The changes were put into the production region in July 2002.

Passive surveillance
Investigation by field veterinary officers and stock inspectors of disease events in livestock, reported by producers, achieves two objectives. The provision of a diagnostic service, by veterinary officers and stock inspectors, for sick animals assists producers to treat, prevent and control disease in their animals, and thereby enhances profitability. Providing this service also enables documenting passive surveillance for both exotic and endemic livestock diseases. Information from passive surveillance can be used for market health assurances in trade. The accumulation of knowledge over time regarding endemic disease conditions in livestock also enhances the advice and extension information that is provided to producers.

There is an active extension program on prevention of diseases such as botulism, tick fever and coccidiosis across the Northern Territory. Advice to property owners is provided on request or following a disease investigation.

Advice may be offered over the phone, or otherwise a property is visited to investigate the history, conduct clinical examinations of stock, and to perform post mortems and collect samples. Following assessment of the property visit and the results of laboratory findings, producers are advised of the outcome, and control measures are discussed. For the purpose of this project, livestock include cattle, buffalo, working horses, camels, goats, crocodiles, pigs and poultry.

Endemic disease
Table 1 shows the number of investigations (passive and active), by region, for the July 2001 to June 2002 period. Field veterinary officers and stock inspectors conducted these investigations, usually by a visit to the property or advice over the phone. This is a crude estimate of activity because an investigation can range from a phone call, to examining one animal, to examining and sampling many animals.

Table 1. Record of investigations by staff to support industry during 2001/2002

	Darwin	Katherine	Tennant Creek	Alice Springs	Total
Antelope	2	-	-	-	*2*
Bird	-	1	-	-	*1*
Camel	3	-	-	1	*4*
Cat	-	-	1	-	*1*
Cattle	**6**	**57**	**25**	**13**	***101***
Crocodile	3	-	-	-	*3*
Deer	1	-	-	-	*1*
Dog	-	5	-	-	*5*
Goat	2	2	-	-	*4*
Horse	7	23	4	3	*37*
Insect	25	2	1	-	*28*
Pig	10	1	-	-	*11*
Poultry	2	2	-	4	*8*
Snake	-	1	-	-	*1*
Wallaby	-	1	-	-	*1*
Wallaroo	-	1	-	-	*1*
Total	**61**	**96**	**31**	**21**	***209***

The 101 cattle investigations were done on 53 properties, and include sampling for the National Transmissible Spongiform Encephalopathy Surveillance Program and sampling for Johne's disease surveillance. These figures indicate a significant increase in the number of cattle investigations compared to last year (77 in 2000/2001). The 'insect' investigations in the Darwin region have increased (about double) from last year, and are still due mainly to sampling of cattle ticks for acaricide resistance testing. There are more horse investigations than last year, but fewer buffalo, camel, crocodile, goat and pig investigations. The total number of investigations has remained about the same as last year (216 in 2000/2001, 182 in 1999/2000, 154 in 1998/99 and 167 in 1997/98).

Diagnostic highlights

Tennant Creek and Alice Springs regions

Brunchilly calf loss observational study
A joint study between staff of Stanbroke Pastoral Company and of DBIRD sought to determine reasons for periparturient calf loss in heifers, which has been up to 25%. Two hundred pregnant heifers on Brunchilly Station were selected for calving in October/November and monitored twice daily during that period. Any observed calf mortality was accompanied by post-mortem where possible. Observations indicated heat and paddock size influenced losses, but there was no indication of contagious disease being a significant cause of mortality. The final report has not yet been completed.

Genetic defects
Seven heifers were drafted on a Gulf property with brachycephalic jaws and joint abnormalities. The cause is probably genetic, causing 'bulldog' craniums and overshot jaws. Stunted and thin, the heifers would probably not have survived the dry season off their mothers.

A calf with a neural tube defect was found on New Crown Station.

Assisting north Australian quarantine strategy
Ted Martin (Stock Inspector, Tennant Creek) assisted Northern Australian Quarantine Strategy staff to sample feral pigs, goats, birds and cattle in the Gulf region. Ted's involvement provided necropsy data to assist tuberculosis (TB) freedom assurance. There were 150 pigs and 33 cattle sampled, all of which were examined for evidence of exotic disease, and for evidence of TB. Some granulomas collected from pigs will have TB ruled out in the laboratory, but there were no such lesions in the cattle. Two submissions for TSE monitoring were also collected.

Botulism in water fowl

Many hundreds of water birds died from botulism poisoning on Ilparpa Swamp during January. The cause was rotting vegetation after good rains in December. Private veterinarians assisted Parks and Wildlife staff to diagnose and treat individual birds. Swans, coots, grebes, waders and stilts died in large numbers.

Plant poisoning
Caustic vine (*Sarcostemma* spp.) poisoning caused deaths in a number of heifers showing nervous signs and collapse in yards on a Barkly Tableland property. The station physically removed the plants from the holding paddock.

A worker at McArthur River Mine collapsed and became blind after wiping his eyes whilst hand pulling *Tecoma stans* (yellow bells) at the mine site. There is no reference to this plant causing this syndrome in the literature.

Exotic disease exclusion
A 16-week old Persian kitten was admitted to the Tennant Creek Veterinary Clinic with severe fly strike. The maggots had invaded the fresh tissue of the abdomen and spine area, and this was a very unusual case. Deep and superficial larvae were removed and prepared for identification to eliminate any possibility of them being the exotic *Chrysomia bezziana* (screwworm fly). The maggots were from a local species of fly.

Horses
A valuable stallion became ataxic and incoordinated on a Barkly Tableland property and died. Despite necropsy and laboratory investigation, the cause of death is unknown. The cause may have been migrating strongyle larvae or a virus.

Four stock horses which showed ataxia and died suddenly on a Barkly Tablelands station were likely poisoned by feed toxins in old work horse feed mix.

Stress
Reported losses of cattle at Bohning Yards indicated 30 cattle had died out of 4,000 processed through the yards during the previous fortnight. One bull that showed ataxia and distress revealed hepatic lipidosis on post-mortem. Although only one necropsy and only two other clinically affected cows were observed, it is likely that stress on cattle not used to human handling and possible poison plant ingestion are major contributing factors. Most cattle dying in this fashion have come from stations where little stock handling occurs.

Lake Nash supplementation trial herd
Sampling of the Lake Nash Supplementation Trial herd was completed during the year. This was an adjunct to the main trial, which focussed on reproductive disease surveillance and correlation of seroconversions with calf loss. A final report is yet to be developed.

Camels
Three camel calves collected from AZRI developed skin lesions. Hair samples were forwarded to Berrimah Veterinary Laboratories cultured *Nocardia* bacteria, as well as other organisms. *Nocardia* is potentially a zoonosis, although it is found incidentally as an environmental contaminant. A skin lesion on the owner necessitated further investigation. Skin biopsies of the worst affected calf revealed severe ringworm as the primary affliction.

Chickens
Seventeen out of 20 chicken poults died from Marek's disease over a three week period on a farmlet in Alice Springs. Another backyard flock lost seven of 12 chickens from Marek's disease. An article in the Australian Veterinary Journal (February) described increased field strain virulence of the virus within the wider industry and the development of a new vaccine to prevent disease. Hatcheries may not yet be using the new vaccine resulting in increased losses in backyard flocks.

Over a four-week period, 45 out of 100 chicken poults died on a farmlet in Alice Springs. Histological examination confirmed lesions consistent with infectious laryngotracheitis (ILT). This is believed to be the first reported outbreak in the Northern Territory. Chickens are normally vaccinated against ILT at the hatchery, but these may not have been vaccinated adequately. Treatment with oxytetracycline was effective in affected birds, and it is likely bacteria were causing secondary infections, resulting in death.

Sentinel herds
Sentinel cattle herds have been maintained on Hayfield, Helen Springs, Rockhampton Downs and AZRI for the purposes of the National Arbovirus Monitoring Program. Cattle are sampled regularly and insects collected by light trap determine vector activity levels.

Sentinel poultry flocks are bled monthly for serological testing for Murray Valley encephalitis virus and Kunjin virus for NT Health and Community Services. The flocks are located in Tennant Creek, Alice Springs and Ilparpa Swamp. Seroconversions at Tennant Creek (7/7) and Alice Springs (1/19) prompted public health warnings.

Weaning losses
Deaths of Brahman weaner cattle (30/1000) subsequent to castration and dehorning were investigated on a Barkly Tableland property. The histological appearance of connective tissue in the haemorrhage from the scrotum of the animal that had the post-mortem showed consistency with histotoxic clostridial infection. *Clostridium sordelli* was cultured from the liver. This bacterium is one of the agents noted for production of gas gangrene or malignant oedema in deep wounds contaminated by soil or faeces, with acute death due to toxaemia. A build up of contamination in yards is not uncommon on some properties in some years. Improved hygiene and measures to reduce contamination levels are being implemented to reduce losses.

Four heavy Santa Gertrudis weaners in a mob of 800 showed distress became recumbent and died acutely on another Barkly Tableland property. Post mortem of two animals showed severe bronchopneumonia, likely to be caused by weaning stress, viral infection and secondary bacterial infection. A second Barkly Tableland property reported similar losses.

Katherine region

Botulism
Deaths of steers one to three years old were confirmed to be due to botulism. These animals had received only one dose of conventional vaccine at weaning, which is less than manufacturer's vaccination recommendations and clearly inadequate to provide sustained protection. Contributing factors included a very dry season and no mineral supplementation program resulting in voracious carcase consumption. At post-mortem, the major significant finding was the presence of bone fragments in the rumen. Several affected animals were seen to substantially recover over a period of days.

A classic outbreak of type C botulism in turkeys caused 25% mortality in the wet season. The source of toxin was several dead birds, which had gone unnoticed. Clinically, birds affected had classic 'limber neck' before becoming recumbent. On post-mortem, no pathology was seen, as expected. Some birds had empty crops and some full, indicating a variable, but in some cases, rapid onset.

Johne's disease
Mycobacterium avium subsp. paratuberculosis was isolated from two dairy cattle initially tested for surveillance. Fortunately most of the herd had been exported or slaughtered, and trace forward actions have now accounted for all known animals from the source herd. A number of in-contact herds are under quarantine pending final laboratory results of exposed animals from these herds. The Territory is free from Johne's disease (Protected Zone) and targeted monitoring will continue of stock at possible risk.

Blue-green algae toxicity
A case of sudden mortality (2%) in breeder cattle was investigated. The case appeared to be consistent with blue-green algae toxicity due to the severity of the syndrome, and the extreme liver and kidney pathology. Natural water was present in the paddock, but unfortunately could not be located due to the extreme scrubby nature of the country. The case was unusual in that it occurred during a period of cool weather.

Phosphorus deficiency
Several instances of 'fragile bone syndrome' were investigated in cattle, where backs were broken in the course of normal yard handling. This fatal problem has been attributed to phosphorus deficiency. In one case with good records, the supplementation intake was estimated to be 4–7 g P per day, but the requirement for these pregnant heifers would have been in the order of 9– 12 g per day. Due to long wet seasons and poor quality pasture, it is likely that the forage would not have filled the gap in P demand. Brittle bones were obvious at post-mortem. No other effects of phosphorus deficiency, in terms of lameness or

reduced fertility, were noticed and it is possible that the problem was due to only a portion of the herd failing to ingest supplement. The calcium/phosphorus ratio in the supplement was within acceptable levels.

Leptospirosis
An investigation of infertility problems in stud cows that had failed to conceive, had delayed conception, aborted or failed to mother, showed that all animals were sero-positive to Leptospirosis hardjo. L. hardjo continues to be a significant zoonosis in the region and its true significance in commercial beef herds is unknown. Vaccination can effectively control this disease.

Tail Rot: Tail rot in cattle continues to be prevalent throughout the region, but no further clues have been uncovered as to its cause.

Darwin Region

Cattle
Deaths in weaners in August 2001 at a property in the Douglas Daly area were investigated. Toxicity was suspected. Deaths stopped once cattle were moved out of the suspect paddock. Sulphur toxicity was determined to be the cause of death, as a large pile was found in the suspect paddock. Deaths stopped once the pile was fenced off. The weaners were then allowed to return to the paddock.

Profuse diarrhoea in 10% of a mob of yearling cattle on a Douglas Daly property was investigated. It appears that the cattle had not developed natural immunity to coccidia due to the use of prophylactic monensin. The diarrhoea developed when the monensin was withdrawn.

Deaths were reported in a mob of cattle on a Darwin floodplain. Initial examination was impossible due to the wet conditions. When the floodplain dried out, an examination revealed bullet holes in the skulls of most of the dead animals.

Antelope
In August 2001 ongoing deaths continued in black buck antelopes on a safari park in the Mary River area. A poor plane of nutrition and high worm burden were implicated as the cause. After drenching and improving the feed, the deaths stopped.

A wildlife sanctuary reported deaths in gemsbok and nilgai over a period of a few months. Animals were found either dead without showing clinical signs, or died quickly after a very short period of lethargy. Post-mortem examination revealed little on gross examination, and the first few post-mortems were performed on animals that were in an advanced state of decay. It was, however, noted that a lot of senna (Senna obtusifolia) was growing throughout areas of the sanctuary. Further deaths allowed more thorough and accurate post-mortems. Signs consistent with senna poisoning were seen including increased creatinine kinase and potassium levels, and muscle pathology. A patch of senna was heavily grazed in an enclosure where all the species had been. It had been treated with a herbicide, which apparently makes the plant more palatable

Poultry
Ongoing deaths and signs of flaccid paralysis in chickens at a commercial pullet shed were investigated. Botulism was diagnosed by mouse inoculation testing. Only one shed was involved.

Buffalo
Tuberculosis was diagnosed in a buffalo from a property in the Darwin area. A total de-stock was carried out on the property and surveillance of neighbouring properties began.

Horses
A horse (foal) in the Darwin rural area was examined after owners noted it was exhibiting strange neurological signs. The owners reported that they had two horses since late December euthanased because of similar signs, which began as lameness, progressed to paresis and then paralysis/neurological signs. The third horse recovered after it was removed from the paddock where all the horses had been housed. Toxicity was suspected. Senna obtusifolia (java bean/senna) was the predominant species in the pasture and, although unpalatable, the horses ate it because they did not have much of a choice. In retrospect, the owners believed another horse had shown early signs but recovered when moved to another property. Senna poisoning is seen more often in cattle and pigs, where neurological signs predominate. Biochemical

tests show increased creatinine kinase and potassium levels. The foal showed very minor changes in these values, and unfortunately blood samples were not collected from the other two horses.

Camels
Camels from Alice Springs that were spelled in Darwin died. The cause of infection was *Burkholderia pseudomallei* (melioidosis), which led to an acute disease, characterised by the formation of small abscesses throughout the lungs. Eleven from one group of 18 camels, and 18 from another group of 21 died after spelling for four days or more in the middle of the Top End wet season. Camels appear to be highly susceptible to melioidosis. The causative bacteria are environmental organisms found in soil and water throughout the Top End. Alternative ways of managing wet season camel exports have been developed.

Crocodiles
Crocodile hatchlings on two crocodile farms in the Darwin area showed signs similar to inappetence and circling. Mycoplasma infection was suspected but no organisms were grown. The crocodiles were put on a trial treatment of terramycin, and appeared to recover.

Pigs
Piglets in the rural area suspected of having an exotic disease were isolated. The piglets had been sick for a few days. Two piglets were showing signs of lethargy, lameness, blisters and discharge from the mouth. Examination showed lesions on the coronary bands of the feet and inter-digital spaces, and also excoriations of the soft palate, and lesions on the snout and in the mouth. Both also had skin lesions consistent with swine pox. The owner reported that a relative had returned from overseas the day before, and evidence was found of swill feeding, and confirmed by the owner. Swine pox virus infection, in combination with a chemical/plant irritant, was suspected (parsley was seen in the pen). However, the diagnostic team ruled out any of the vesicular diseases. Samples were taken and sent to the Australian Animal Health Laboratory in Geelong. The samples were negative for any vesicular diseases. Swine pox was diagnosed on clinical presentation and histology by Berrimah Veterinary Laboratories.

A number of deaths at a commercial piggery were investigated. Pneumonia, pyelonephritis and cystitis were the most common causes.

PROJECT: Emergency Animal Disease Preparedness

Project Officers: **K. de Witte and Pastoral Division Staff**

Location: NT Wide

Objectives:

Participate in contingency planning and training for emergency animal disease preparedness.

Ensure that DBIRD staff, relevant organisations and pastoralists have a continuing high level of awareness in relation to the threat of emergency diseases.

The *Protect Australian Livestock Campaign* is a national coordinated awareness project for emergency animal diseases (EAD) that now runs year round. The Territory contributed two news events that were used. There was no increase in calls to the Emergency Animal Disease hotline during the year. The hotline continues to receive a small number of important calls. One of these resulted in an investigation into the feral pig population in coastal central Arnhem Land. Fortunately, all results were negative for exotic vesicular diseases.

Foot and mouth disease (FMD) awareness workshops were held in all four main regional centres involving relevant departments and organisations and the cattle industry. A major outcome has been the NT Operational Response Plan for FMD, which details how the Territory will respond to a disease outbreak in the context of its limited resources. The plan is a derivative of AUSVETPLAN and contains a number of appendices with prepared documentation, staffing and siting information for an FMD response which is the worst case scenario. The plan was exercised this year with an investigation of sick piglets in the Darwin rural area and submission of samples to the Australian Animal Health Laboratory, Geelong. Fortunately, the disease was only swine pox, a local condition, and the plan was fine-tuned and further awareness material produced. Other EAD submissions have been made, mainly of maggots for screw worm fly exclusion.

Two veterinary officers and five stock inspectors obtained experience by assisting in the FMD outbreak in the United Kingdom. Their participation was extremely useful in gaining experience with diagnosis, slaughter and disposal methods of livestock and also in the operation of local disease control centres. The outbreak in the United Kingdom created a lot of local community and industry interest. As a result there has been increased promotion of FMD awareness through newsletters, media interviews and presentations at Northern Territory Cattlemen's Association meetings, DBIRD Primary Industries Group and regional meetings and field days. One stock inspector conducted 14 presentations, which were well received by the cattle industry. On this theme, property bio-security has been a topical issue and a paper has been produced for inclusion in the NT Operational Response Plan.

As part of the national emergency animal disease preparedness (EADP) training program, two veterinary officers attended a controllers’ workshop and were assessed. Further local training is planned in data management (ANEMIS), infected premises operations (site supervisors) and movement and security operations (checkpoints). The NT continues to send veterinary officers to exotic disease courses at the Australian Animal Health Laboratory (AAHL). The EADP competency standards and assessment methods for the various tasks within an emergency animal disease response are on the DBIRD Primary Industries Group intranet site. A register of competencies is maintained and is the basis for targeting gaps in training.

Departmental officers contribute to the technical and policy management of the national program at several levels. Highlights include:

Commissioning the Bovine Spongiform Encephalopathy (BSE or mad cow disease) AUSVETPLAN manual.

Revision of various other AUSVETPLAN manuals (including foot and mouth disease, carcase disposal, and control centre management).

Contributions to the policy and action plans for a livestock standstill, zoning in a disease outbreak and free zone surveillance requirements.

Most notably, all parties have signed the EAD cost sharing agreement. This represents a tremendous achievement and will enable the necessary national response to an EAD.

Inspections of garbage disposal facilities in towns, remote communities and stations were conducted throughout the Territory by stock inspectors to determine the risk of inadvertent or deliberate swill feeding to pigs. Swill is garbage containing mammalian or poultry protein and is not allowed to be fed to pigs. The level of awareness was found to be high and few significant problems were encountered. Public vigilance and reporting is appreciated.

The honeybee industry conducted a well–attended, industry awareness workshop in Darwin with funding from Animal Health Australia. Several beekeepers were accredited to assist with an exotic bee or bee disease response as occurred in 1998.

PROJECT: Honeybee Industry

Project Officers: K. de Witte and V. Simlesa

Location: NT Wide

Objective:

Provide technical advice, disease investigation and regulatory services to the honeybee industry.

There is concern over the potential introduction of exotic bees and parasitic mites after recent experiences in Australia and New Zealand. The Asian honeybee *Apis cerana* was detected in Darwin in 1998 and subsequently eradicated.

The national sentinel hive program (NSHP) has been established to detect the presence of the exotic *Varro*a mite which is a natural ectoparasite of the Asian honeybee. The *Varroa* mite has switched to the European honeybee (*Apis mellifera*) as a host, and has become a serious pest in the bee world. There are three highly specialised species of *Varroa* mite, of which *V. jacobsoni* has the widest distribution and *V. destructor* poses the greatest threat. The *Varroa* mite established in New Zealand in 2000 while Australia remains free of it.

The NSHP includes both hives and log traps. The European honeybee hives are established at Darwin Port and East Arm Port. The hives were donated and are maintained by a local beekeeper. Monitoring is conducted every three months. A commercially produced pest strip ('Bayvarol strips'), specifically designed for the detection of the *Varroa* mite is placed within the hive for 24 hours. A sticky board is placed at the bottom of the hive to capture any *Varroa* mites detected by the Bayvarol strip. Sticky boards are submitted to the Entomology Section after 24 hours for identification of possible mites.

The log traps have been established to monitor for the presence of the Asian honeybee. The traps no longer have a pheromone lure placed inside. The trap design has been tested and it was found that the hollow palm tree trunk was the most appealing to the Asian honeybee. The traps are designed with a small access hole on the side for bee entry. Each month the log traps are checked and the presence of any honeybees is recorded and if any are present, they are sampled. There are five traps established in the Darwin region, one at Darwin Airport, two in the East Arm area and two in the Darwin Port area. One log trap is also established at Gove and one at Groote Eylandt. Pheromone lures are not utilised in the log traps; detection of adult Asian honeybees is brought about by the Asian honeybees' preference for hollow palm logs.

A display of honey tasting, quarantine matters and a glass hive of live bees were presented at the Royal Darwin Show.

Honey samples were collected from the major beekeepers for the national residue survey.

The apiary officer attended the Northern Territory Beekeepers' Association Annual General Meeting in Darwin. The apiary officer also presented a BARC seminar on quarantine awareness and contingency planning for exotic bee incursions.

An information session for NT beekeepers was conducted on behalf of the Rural Industries Research and Development Corporation. Two guest speakers (Keith McIlvride and Fred Benecke) were involved in obtaining information for the re-vamp of the publication *Commercial Bee Keeping Practices*. This information will be utilised to include a section on honey production in the NT in the re-vamped publication.

PROJECT: Legislation

Project Officers: **B. Radunz, Project Leaders and Parliamentary Counsel**

Location: NT Wide

Objectives:

Amend stock and meat legislation as required.

Amalgamate the various stock legislation into a Stock Act.

Conduct a legislation and compliance program.

There are currently five Acts, with associated Regulations, relating to stock (*Stock Diseases Act, Stock and Travelling Stock Act, Brands Act, Exotic Disease Compensation Act,* and *Hormonal Growth Promotants {Stock} Act)*. The goal is to amalgamate the legislation into a Stock Act and concurrently remove outdated and unnecessary legislation.

In response to national preparedness planning for foot and mouth disease and for bovine spongiform encephalopathy there is national agreement to ensure legislation exists in all jurisdictions to implement sixteen critical success factors. The *Stock Diseases Act* will be amended to improve response capability with a minimum risk of challenge.

Notices by the Minister or the Chief Inspector of Stock are prepared to provide the necessary legislative powers to enforce required stock movements within the Northern Territory or for importation of stock into the Northern Territory to prevent the spread of disease.

There is a compliance program to audit compliance with the more important regulatory controls. If non-compliance is detected the response may be to initiate a prosecution, issue an infringement notice, or provide education and a warning.

Activities
The new government affirmed the urgent amendment of the *Stock Diseases Act* and the amalgamation of the stock legislation into a Stock Act. Further consultation, review and amendment are due during 2002 and 2003.

The following notices were gazetted:

1. The importation of stock relating to Johne's disease.
2. Movement restrictions relating to Parkhurst resistant ticks.
3. Movement restrictions relating to cattle ticks.
4. Compensation rates for buffalo and cattle.

Compliance program

Audits completed.
Health certificates and waybills

Abattoir	1
Export depots	9
Properties	55
Ruminant feed ban – retailers	5
Saleyard	76
Tick condition - horse events	8

There were no cases of non-compliance detected during the audits.

PROJECT: Livestock Identification

Project Officers: **K. Small and N. Hamilton**

Location: NT Wide

Objectives:

Ensure that a livestock identification and tracing scheme can provide a consistent traceback system across Australia.

Ensure compliance with the Northern Territory Brands Act and Regulations and the Stock Diseases Act and Regulations.

Consumer demands for food safety have highlighted the importance of being able to trace meat products back to the property of origin. The Australian cattle industry aims to stay ahead of its competitors with this important trade issue.

National livestock identification scheme (NLIS)
A system of permanent identification of cattle using radio frequency identification devices (RFID) contained in a rumen bolus or an ear tag has been adopted by NLIS.

Devices are approved for use in the Northern Territory pursuant to Regulation 20 of the Stock Diseases Regulations. The conditions of use are also specified.

The European Union (EU) has accepted the NLIS system of permanent identification as the basis of a traceback system to allow access to its beef market.

Meat and Livestock Australia has developed a national database which will keep records of all permanently identified stock.

All NT cattle herds have been issued with a property identification code (PIC). The updated pastoral database is fully operational. The database stores all cattle property details including livestock numbers, property owner and manager details. Regional staff has access to the pastoral database with the distribution of an updated compact disc.

Implementation of NLIS
During 2001/2002 the NT participated in two working groups set up at the request of Primary Industries Standing Committee to progress the implementation of a national approach to livestock identification and tracing. The lack of progress towards reaching a consensus only reflects the wide-ranging needs of different industry sectors.

Experience in the northern cattle industry has shown that electronic cattle identification reduces cattle handling efficiency, and adds significantly to labour costs. The operational performance of the system will have to be improved if commercial uptake is to be achieved. The present operational performance is good enough for the feedlot sector but unsatisfactory for commercial breeding herds and large saleyard operations.

National vendor declarations (NVDs)
Some status and industry groups are promoting the compulsory use of NVDs. The NVD is now being used to provide similar information to that supplied on the Northern Territory Waybill.

Brands
Changes to the Brands Regulations have been implemented in relation to branding positions and cross branding. No changes to *the Brands Act* will be made until the new Stock Bill is produced.

PROJECT: Meat Industries

Project Officers: S. Sell and R. McFarlane

Location: NT Wide

Objective:

To ensure compliance with national standards, and foster export and domestic markets for all sectors of the NT meat industry.

The Department of Business, Industry and Resource Development (DBIRD) is responsible for regulating the meat industry in the Northern Territory, from slaughter through to processing and storage for wholesale.

The Department of Health and Community Services (DHCS) regulates meat retail outlets.

DBIRD licenses and regulates:

- Abattoirs that slaughter all types of animals, including poultry and crocodiles.
- Wholesale meat processing, including the manufacture of smallgoods.
- Game meat slaughter.
- Game meat processing.
- Pet meat slaughter.
- Pet meat processing.
- Bait meat (slaughter/processing).
- Cold stores (domestic meat storage).

DBIRD's regulatory role for the meat industry in the NT is enabled by the *Meat Industries Act* 1996 (Northern Territory), the Meat Industries Regulations (Northern Territory) and the following National Standards and Codes of Practice:

- Australian Standard for Hygienic Production of Crocodile Meat for Human Consumption.
- Australian Standard for Hygienic Production of Natural Casings Meat for Human Consumption.
- Australian Standard for Hygienic Production of Ratite (Emu/Ostrich) Meat for Human Consumption.
- Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption (Second Edition).
- Australian Standard for Hygienic Rendering of Animal Products.
- Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption.
- Australian Standard for the Hygienic Production of Game Meat for Human Consumption.
- Australian Standard for the Hygienic Production of Rabbit Meat for Human Consumption.
- Livestock at Slaughtering Establishments Model Code of Practice for the Welfare of Animals.

These standards are non-prescriptive (outcome based) and initiate change from the historical meat industry compliance method of online government inspection to a system of company self regulation via government approved and audited hazard analysis and critical control point (HACCP) based Quality Assurance (QA) programs.

Activities
The past 12 months have seen the number of licensed wholesale meat processors increase from seven to 13.

The new licensees are all existing meat businesses that were either previously unaware of regulatory requirements or were retail outlets that have expanded their wholesale operations.

A recently drafted (yet to be approved) memorandum of understanding between DBIRD and DHCS identifying DBIRD as the agency responsible for enforcement of food safety regulatory requirements in retail meat premises that are also licensed as wholesale meat processors.

Assistance with HACCP and QA is provided to all new licensees.

AQIS has reissued a blanket exemption to the *Export Control Act* allowing domestic meat from NT licensed abattoirs and processors to be exported to East Timor. Tenarra abattoir also has current exemptions allowing export of domestic meat to Indonesia and Brunei. All domestic meat exported requires Northern Territory health certification, issued by DBIRD.

Progress report
Meat industry licences issued:

- 12 abattoir
- 13 wholesale processors
- 2 pet meat processors
- 8 pet meat slaughter
- 7 game meat slaughter

Abattoir details:

- 8 red meat (1 export, 7 domestic)
- 3 crocodile (2 export, 1 domestic)
- 1 poultry (domestic)

Barkly Meats Tennant Creek abattoir and Consolidated Meat Groups Katherine abattoir have not opened for a 2002 slaughter season.

Wholesale processor details:

- 10 independent boning and packing operations
- 3 smallgoods manufacturers.

Meat inspection
DBIRD does not provide meat inspectors to industry. The sectors of the meat industry that require meat inspectors must employ their own.

DBIRD's only field regulatory function is auditing. Audit frequency varies depending on throughput and performance at previous audits.

Game meat
Twelve participants completed a wild animal field-harvesting course held by DBIRD during July 2002.

There are currently no game meat field depots operating in the NT, however wild pig prices are rising and several game meat licensees are negotiating with Queensland export game meat abattoirs.

PROJECT: Monitoring Cattle Dip Strength

Project Officers: K. Small and Regional Staff

Location: NT Wide

Objectives:

Ensure government and private dipping facilities are run at correct strength.

Provide an advisory service on correct dip chemical usage, plunge dip management and choice of acaracide.

Provide a dip analysis service.

The use of plunge dips has now increased due to the withdrawal of Bayticol Pour-On® from the market.

The project involves provision of dip sample bottles, dip sampling sticks and an analysis service for industry and government. Dip samples are collected by station staff, veterinary officers and stock inspectors. Samples are sent to Berrimah Agricultural Research Centre Chemistry Section for analysis. Collectors, station owners/managers and program managers are notified of the results and appropriate advice is given.

A total of 40 dip samples were analysed from NT properties during 2001/2002. Of the 40, 19 samples were at correct strength, two samples were over-strength and 19 samples were under-strength. Corrective action was advised in each case of over- or under-strength.

Several dips have been changed from synthetic pyrethroids to amitraz in response to resistance to synthetic pyrethroids in the Darwin region.

PROJECT: Monitoring and Eradication of Cattle Tick Strains Resistant to Chemicals

Project Officers: K. Small, D. Russell and I. Doddrell

Location: NT Wide

Objectives:

Locate chemically resistant strains of cattle tick on NT properties and prevent their spread.

Advise industry on chemical control of any detected resistant cattle tick strains.

Prior to April 1999 there were no known cattle tick strains resistant to synthetic pyrethroids or amitraz in the NT. Previously some resistant strains to organic phosphates were detected during the 1970s and 1980s. Organic phosphates were banned as an acaracide in 1987.

There are strains of cattle ticks resistant to one or more acaracides in Queensland. All cattle from the tick-infected areas of Queensland require a clean inspection followed by plunge dip to enter the NT. Despite this control, there is a low level of activity to monitor for resistant ticks as there may be illegal movements or inspectors in Queensland may not detect ticks. Although there is little cattle tick control in the NT to improve production, the widespread establishment of resistant ticks would have a significant effect on achieving tick-free cattle for export overseas and interstate.

Fully engorged female cattle ticks are collected in the field and sent to the Animal Research Institute at the Queensland Department of Primary Industries, for processing and larval packet testing against a number of tickicides. Collectors and station owners/managers are given the results and appropriately advised. The program targets properties that report poor tick kill and properties on which pour-on synthetic pyrethroids are used for cattle tick or buffalo fly control.

Parkhurst strain resistant ticks (resistant to synthetic pyrethroids e.g. cypermethrin and flumethrin as in Bayticol®, Barricade 'S'® and Blockade-S®) were found on two properties in the Mary River area in April 1999. Monitoring activity commenced in the Mary River area on the properties with known Parkhurst strain resistant cattle ticks and the neighbouring properties. Any reports of poor tick kill following treatment are investigated. Parkhurst strain resistant cattle ticks were found on a third property during 2000. In 2001 a further two properties were found to have Parkhurst strain resistant ticks.

Activity 2001-2002
The government funded eradication program ended in June 2001.

After consultation with the Northern Territory Cattlemen's Association and the Northern Territory Livestock Exporters' Association the stock movement conditions relating to properties with Parkhurst strain resistant ticks were modified, and a program aimed at assessing the status of ticks on all Darwin region properties was commenced. In the year ending June 2002 a further three properties were confirmed to have Parkhurst strain resistant ticks, bringing the total number of infected properties to eight.

One of the original infected properties has shown a negative result for Parkhurst ticks in both 2001 and 2002.

Several new plunge dips have been constructed in the Darwin region. These dips are being charged with amitraz. The construction of new dips and the implementation of new movement conditions have improved market access for owners of infected properties.

Advice was provided at industry meetings and through rural newsletters on alternatives to using synthetic pyrethroids to control cattle ticks.

SUBPROGRAM: TB Freedom Assurance Program (TBFAP)

PROJECT: Tuberculosis Eradication

Project Officers: **B. Radunz, Regional Veterinary Officers and Staff**

Location: NT Wide

Objectives:

Monitor cattle slaughtered at abattoirs to maintain TB free area status.

Turn-off of cows previously exposed to TB infected animals to remove the remaining group of risk cattle.

Deal with TB case herds to the satisfaction of the owner and a national TFAP Property Program Group.

The Tuberculosis (TB) Impending Free Area declaration in November 1992 was a culmination of years of work by many pastoralists, private vets and departmental staff, with the expenditure of $192m. The Northern Territory was declared a Free Area for TB at the end of 1997 and so achieved the goals of the Brucellosis and Tuberculosis Eradication Campaign (BTEC). A further $39m was spent during the period from 1993 to 1997.

A five-year monitoring program, known as the TB Freedom Assurance Program (TFAP), was agreed to and funded from 1998 to 2002 by the State and NT governments, cattle industry and the Commonwealth government. The national forward estimate for TFAP was $33m, of which expected expenditure in the NT is $13m.

It is expected that a small number of TB cases will be found in cattle previously exposed to TB, despite having completed the testing programs.

Activities
The TFAP program is on track to achieve the objectives.

The national granuloma submission program has continued. TB surveillance has continued on herds with previous infection since 1 January 1988.

Eradication
There were no ongoing eradication programs.

Breakdowns
One TB case was detected in January 2002 in a small buffalo herd near Darwin. The TB case was an old cow slaughtered at a local domestic abattoir. The cow was one of the original buffalo heifers retained from a previously infected area in the mid 1980s. There were 96 buffalo and cattle mustered and sent to slaughter. Forty eight buffalo and cattle that could not be mustered were destroyed.

National granuloma submission program (NGSP)
TB surveillance at abattoirs has dropped to very low levels in the northern third of the Northern Territory due to the dominance of the live export market.

During the year there were about 5,435 cattle and buffalo slaughtered at NT abattoirs. There were five granulomas detected, with one confirmed as TB.

TB testing July 2001 to June 2002

	Number tested	Number of reactors	Number with TB
Cattle	48,635	104	0

Testing was done on 16 properties.

Voluntary monitor programs
Cattle previously exposed to TB infected animals remain a very low, but possible, risk of undetected TB cases despite completion of the eradication program (at CF2 or CF3 status). Of the estimated 24 million cattle in Australia there were about 200,000 on 70 properties in this risk category in 1997. The national cattle industry decided that the owners of these properties should adopt risk management strategies to minimise the risk and the scope of a possible future TB case.

Relevant owners were contacted and a voluntary monitor program was proposed. The program includes continued segregation of the cattle previously exposed to TB infected animals, early turn-off of the cattle and a TB test in 2001 if turn-off during 2000 was not possible. The national cattle industry provided about $4 million to accelerate the turn-off. This was in the form of a spay subsidy and a freight rebate. Owners who agree to, and implement, a voluntary monitor program, are eligible for all available financial assistance for the program and in the event that a TB case is found. Owners who do not adopt a voluntary monitor program are only eligible for compensation if de-stocking is done.

In 1997 there were 50 properties in the NT which records indicated may have had stock remaining that were previously exposed to TB infected animals. At the end of 2001 29 properties had completed the voluntary monitor program. The owners of three properties decided not to adopt the voluntary monitor program. Nineteen properties have conducted a program but have not yet completed it.

At the end of 2001 there had been an increase in category A cattle from 3,350 to 4,872 due to another group identified on one property. Category B cattle decreased from 54,000 to 49,660. Category A cattle are breeders that were 12 months of age or older when exposed to TB infected stock. Category B cattle are progeny of cattle de-stocked due to TB or progeny of category A breeders.

Expenditure during 2001/02

Operations	$488,064
Compensation	$110,252
Mustering subsidy	$244,358
Interest subsidy	$0
Freight rebate	$47,611
Type G	$8,788
Type H	$0
TOTAL	**$907,901**

PROGRAM: Berrimah Veterinary Laboratory

Objective:

Provide a quality assured veterinary laboratory service.

The Berrimah Veterinary Laboratories (BVL) provide an ongoing diagnostic service in the broad fields of veterinary pathology and veterinary virology. BVL also conducts research projects and participates in quality assurance programs to ensure that the quality of tests carried out at BVL meets national and international standards.

BVL is a National Association of Testing Authorities (NATA) accredited laboratory in the field of veterinary testing in the disciplines of anatomical pathology (necropsy, histopathology and cytology), microbiology (bacteriology, mycology and virology), parasitology and serology of infection.

A total of 1,883 submissions were received and processed during the year at BVL. Each submission may consist of one or more specimens and each specimen may undergo one or more tests in one or more of the 12 sections of BVL.

The 1,883 submissions consisted of 32,336 specimens and generated some 59,719 individual tests in gross and microscopic pathology, bacteriology, clinical pathology, parasitology, serology and virology. The numbers of tests and investigation reasons were:

- 9,860 tests for diagnosis of disease in production animals;
- 66 tests associated with monitoring for bovine tuberculosis;
- 11,793 tests for export and movement certification and regulatory purposes;
- 2,750 tests on a service charge basis for companion and performance animals, aviary birds and native fauna;
- 22,353 tests for sentinel herd and flock monitoring;
- 6,008 tests for research programs;
- 6,409 tests for surveillance programs;
- 480 tests for quality assurance.

BVL participates with 24 laboratory tests in the Australian National Quality Assurance Program (ANQAP) for veterinary serology and virology. BVL also participates in quality assurance programs in bacteriology and anatomical pathology. All test results obtained at BVL fell within the respective acceptable variation ranges.

The water microbiology laboratory, which is integrated into BVL's management structure but which has a non-veterinary client base, tested 5,973 water samples from various sources.

Table 1. Laboratory submissions by region and by species

	Darwin	Katherine	Tennant Creek	Alice Springs	Interstate/ Overseas	Total
Antelope	9					9
Banteng	1					1
Bat	12	1				13
Bird (cage & wild)	19	1				20
Buffalo	33				5	38
Camel	3			7		10
Cat	42		1			43
Cattle	181	197	39	36	22	475
Clam	1					1
Crab	24					24
Crocodile	12					12
Deer	1					1
Dog	397	5	1		7	410
Fish	99			1	1	101
Goat	14	6			4	24
Horse	49	31	4	3	4	91
Human	1				10	11
Insect	96	37	13	9		155
Monkey	2					2
Mouse	1					1
Mussel	1				4	5
Native fauna	55	3		3		61
Pearl oyster	34				2	36
Pig	85	9			6	100
Poultry	71	16	6	20	2	115
Prawn	8				4	12
Rabbit	1					1
Rat	11					11
Sheep	20				4	24
Turtle	2					2
Other	39	1		1	29	70
Total	1,324	307	64	80	104	*1879

* This figure is based on date collected.

Table 2. Type and number of laboratory submissions

Diagnostic	498
TFAP**	114
Export	25
Movement	33
Regulatory	7
Sentinel	293
Research	235
Survey	101
Fee for Service***	527
Quality Assurance	46
Other	4
Total	******1883**

** TFAP: tuberculosis freedom assurance program
*** Companion and performance animals, aviary birds and native fauna
**** This figure is based on date received at BVL

SUBPROGRAM: Diagnostic Pathology

PROJECT: Diagnostic Pathology

Project Officers: **A. Janmaat, J. Humphrey (50%), L. Melville (25%), C. Shilton, S. Benedict, L. Small, G. Paterson, L. Chambers, M. Mahoney, D. Cumberland, R. Wilson, N. Cox, C. Day, S. Auman and N. Elliot.**

Location: BVL

Objective:

To provide a quality assured veterinary pathology service to support diagnostic, regulatory and research programs in livestock health and production.

The sub-program is divided into the sections of gross pathology, histopathology, cytology, bacteriology, parasitology, serology, clinical chemistry, haematology and urinalysis - the last three sections fall under the heading of clinical pathology. Water microbiology is also a section of the pathology area. It has a non-veterinary client base.

Gross pathology

Submissions 198

The activity of this section consists of post-mortem examinations of cadavers and gross examination of pieces of organs and tissues. The range of species is large and submissions included Aquaculture: finfish 61, crustaceans 6, pearl oysters 22 and other molluscs 4 (47% of total); poultry 15, dogs 15, pigs 11, crocodiles 11, sheep 9, cattle 8 and goats 5.

- Melioidosis, is a common disease in the Darwin area caused by the bacterium *Burkholderia pseudomallei*. It was diagnosed in goats, camels, pigs, a sheep, a cat, and in a monkey

- There was a recurring problem with necrotic enteritis and chronic peritonitis in cultured barramundi. The condition appears to be associated with increased pellet size of the feed and low water temperature. Low water temperature was also associated with mortalities in imported and local barramundi fingerlings. The parasite *Epitheliocystis* sp was isolated from the gills of the imported fish

- Botulism in birds is a common diagnosis based on clinical signs and lack of post-mortem abnormalities. Confirmation is by the mouse toxin protection test. The disease was diagnosed in backyard chickens, ducks, geese and in broiler chickens

- *Streptococus suis* II was isolated from a number of pigs. The disease is characterised by pneumonia and meningoencephalitis

Histopathology

Submissions 536

Of the total submissions, 10 were for cattle and six for buffalo under the Tuberculosis Freedom Assurance Program either as lesions from reactors or as lesions collected at abattoirs under the national granuloma submission program (NGSP). The brains of 27 cattle were examined as an ongoing NT contribution to the national transmissible spongiform encephalopathy surveillance program. This program is designed to demonstrate freedom from BSE and scrapie, and to provide early detection should these diseases occur.

- The NGSP worked well during the year. A granulomatous lesion in the bronchial lymph node of a buffalo cow was detected at the Litchfield Abattoir and forwarded to BVL. A histologically positive diagnosis of tuberculosis was reached within 48 hours after slaughter

- Lesions in a gemsbok were consistent with Coffee Senna (*Cassia occidentalis*) poisoning. The paddock had been sprayed with the herbicide 2,4 D which apparently makes the plant more palatable

- Pox-like inclusion bodies were seen in samples from a pig which was subject to foot and mouth disease exclusion.

This section participates in the QDPI and the national registry of domestic animal pathology and histology quality assurance programs.

Cytology

Submissions 78

Submissions from private practitioners on a fee for service basis accounted for 63% and submissions for diagnostic purposes from production animals accounted for 27% of the total.

Bacteriology

Submissions 565

Tuberculosis submissions accounted for 20% of the total, diagnostic submissions for 33% and fee for service submissions fort 39%.

Interesting isolations included:

- *Streptococcus equi* subspecies *equi* from horses which confirmed an outbreak of strangles in Alice Springs.

- *Providencia rettgeri* which continues to be a common isolate from septicaemic juvenile crocodiles.

- *Pythium* sp (a common isolate from swamp cancer in horses) from a non-healing inflammatory process near the tail of a dog and a *Mycobacterium* sp from a granulomatous inflammatory process in a cat.

- *E. coli* from four red-winged parrots from Palmerston where “hundreds’ of the birds had died.

- *Actinomyces canis*, a new species described in 2000, was isolated from peritonitis in a dog which had died suddenly.

The section participates in the IFM proficiency testing program for veterinary microbiology and the three Leptospira MATs are part of ANQAP proficiency testing.

Parasitology

Submissions 242

- A wide variety of parasites were identified in aquaculture species.

- Anthelmintic resistance in goats was investigated.

- Feather cysts in a red-collared lorikeet were identified as the mite *Harpirhyncus rosellanicus*.

The section participates in a faecal egg count proficiency testing program run by Agriculture WA..

Serology

Submissions 215

Sentinel submissions for bluetongue ELISA testing were the biggest group at 51% followed by diagnostic submissions 20% and export submissions 7%.

Eight tests conducted in the section are part of ANQAP proficiency testing.

Clinical pathology

Clinical Chemistry

Submissions 130

Diagnostic submissions comprised 62% of the total followed by surveillance submissions 19%.

The Section participates in the BIORAD international quality assurance program for clinical chemistry.

Haematology

Submissions 203

Diagnostic submissions comprised 41% of the total followed by fee for service submissions 26%. Anaplasmosis was diagnosed in Top End cattle.

The Section participates in the RCPA (Royal College of Pathologists of Australia) haematology quality assurance program.

Urinalysis

Submissions 32

Submissions from private practitioners on a fee for service basis were 84% and submissions for diagnostic purposes from production animals were 16% of the total.

Water microbiology

Samples 5937

Most samples come from drinking water supplies and are subjected to three individual tests to determine whether or not the water is potable.

SUBPROGRAM: Virology

PROJECT: Diagnostic Virology

Project Officers: **L. Melville, N. Hunt, R. Weir, M. Harmsen, S. Walsh, N. Cox, C. Day, S. Davis and D. Flanagan**

Location: A.L. Rose Virology Laboratory, Berrimah Farm

Objective:

Provide of an accurate, efficient and reliable veterinary virology service to support diagnostic, regulatory and research programs in livestock health and production.

Background:

The diagnostic virology service comprises both virus isolation and identification and serology. An increasing number of samples associated with aquatic animals were received during the year

Results:

During the year 117 submissions were received for diagnostic virus isolation, electron microscopy (PCR). Bovine ephemeral fever (BEF) virus was isolated from cattle. A number of orbiviruses were isolated from macropods including Eubenangee group and Wongorr group from agile wallabies and Wallal from a Wallaroo. Viruses identified by electron microscopy included nodavirus from barramundi fingerlings, adeno-like virus from oysters and papova-like virus from a pig. A total of 207 submissions were received for diagnostic serology, including 11 for export testing. A further 19 submissions were received from NAQS and other surveys with 74 submissions from research projects.

Export testing consisted of 3,320 cattle sera for enzootic bovine leucosis (EBL), 11 horse sera for equine infectious anaemia (EIA) and two goat sera for bluetongue and CAE.

The Australian National Quality Assurance Program provided quality assurance tests for agar gel imunodiffusion tests for EBL, BVD, EIA, BEF, epizootic haemorrhagic disease, bluetongue and Aino. Serum neutralisation tests were performed for bluetongue, BEF, Akabane and Aino. haemagglutation inhibition tests were performed for Newcastle Disease Virus.

A total of 28,473 serological tests were performed during the year.

PROJECT: National Arbovirus Monitoring Program (NAMP)

Project Officers: **L. Melville, N. Hunt, M. Harmsen, R. Weir, S. Walsh, N. Cox, C. Day, D. Flanagan, G. Bellis and S. Davis**

Location: BHF, BARC, DDRF, KRS, VRRS, AZRI, Rockhampton Downs, Mt Sanford, Riveren, McArthur River, Helen Springs, Hayfield

Objective:

Support trade by providing information to meet Australian Quarantine and Inspection Service (AQIS) requirements for export protocol negotiation and certification.

This is achieved by:

Bluetongue early warning - by the dynamic surveillance of the northern bluetongue endemic area to detect any new viruses or vectors entering Australia and monitoring any southern spread.

Controlling important insect-borne endemic disease - by monitoring for endemic virus activity and the insect vectors which transmit these viruses.

Background:

NAMP is an integrated national program jointly funded by industry and governments to monitor the spread of economically important insect borne viruses of livestock and their insect vectors.

Method:

Monitoring is achieved by using sentinel herds at various sites around the Northern Territory, which are bled at regular intervals and tested for antibodies to a number of viruses. At BHF, weekly blood collections are made and virus isolations performed. Monthly light trap collections of insects are also made at each site.

Results:

1. *Sentinel herd serology and virus isolation*

Beatrice Hill Farm
A total of 222 viruses were isolated from the following groups:

Bluetongue	type 1	April –May	23
Ephemeral fever			2
EHD			64
Ungrouped/untyped			133

Monthly serology also indicated Akabane activity in December and January. BEF activity was recorded in October, April and May and Palyam from December to April. EHD activity occurred from December to March.

Berrimah
Monthly serology indicated the following activity:

Bluetongue	June
Akabane	November, January - March
BEF	November - December
Palyam	January
EHD	March

12 bluetongue isolates were made

DDRF
Monthly serology indicated the following activity:

Bluetongue	March - June
Akabane	November - February
BEF	November, January, February, April
Palyam	September, December - February

Six bluetongue isolates were made

KRS
Monthly serology indicated the following activity:

Akabane	January, April, June
BEF	January, May
Bluetongue	February - May
EHD	March
Palyam	February – April

12 bluetongue isolates were made

VRRS
Monthly serology indicated the following activity:

Akabane	July – September, December
BEF	December, April
Palyam	December

Mt.Sanford
No arbovirus activity was detected.

Riveren
No arbovirous activity was detected.

Rockhampton Downs
The only arbovirus activity detected was BEF in May.

Helen Springs
No arbovirus activity was detected

Hayfield
Arbovirus activity detected included BEF in April and Palyam in October and April.

AZRI
No arbovirus activity was detected.

2. Entomology

Insect numbers were high at all sites following the higher rainfall during the wet season. The most widespread vector, *C. brevitarsis,* was identified at Beatrice Hill Farm, Berrimah, DDRF, KRS, VRRS, Hayfield, McArthur River and Mt Sanford. *C. fulvus*, the most efficient vector, was only found at BHF, Berrimah, and DDRF. *C. wadai* was found at BHF, DDRF, Gove and KRS. *C. actoni* was found at BHF, Berrimah, DDRF and KRS.

PROJECT: Monitoring for Murray Valley Encephalitis (MVE) and Kunjin Viruses for Territory Health Services

Project Officers: L. Melville, N. Hunt, S. Aumann and N. Cox

Location: Darwin, Katherine, Tennant Creek, Alice Springs, Gove

Objective:

To detect flavivirus (MVE and Kunjin) activity through poultry sentinel flocks which are bled monthly and tested for antibodies to these viruses.

Background:

Sentinel chickens are used to monitor flavivirus activity in Australia. Currently twenty six flocks are maintained in the north of Western Australia, seven in the Northern Territory, nine in New South Wales and ten in Victoria. The aim is to provide early warning for the potentially fatal disease in humans caused by the viruses MVE and Kunjin.

Results:

Sentinel flocks were located at Leanyer, Howard Springs, Beatrice Hill Farm, Katherine, Tennant Creek, Alice Springs, Ilparpa swamp and Gove. Seroconversions to MVE were widespread, occurring at:

Tennant Creek in February
Beatrice Hill in April and May
Katherine in November and March
Alice Springs in March
Leanyer in May

Seroconversions to Kunjin occurred at Leanyer in April, Howard Springs in March and April and Beatrice Hill in April.

PROJECT:	**An Assessment of *Culicoides* spp Attacking Livestock Under Cover**
Project Officers:	**L. Melville, N. Hunt, G. Bellis and D. Pinch**
Location:	Beatrice Hill Farm and A.L. Rose Virology Laboratory, Berrimah Farm

Objective:

To monitor culicoides spp attacking cattle when under cover in simulated holding and transport situations.

Background:

Largely qualitative and anecdotal evidence suggested *Culicoides* spp would not enter covered areas and this could be used as a method of protection for cattle travelling through a bluetongue endemic area. This effect had not been quantified or validated statistically. Biosecurity Australia provided funding for the work.

Method:

Sixteen head of cattle of uniform colour and size were divided into four groups. Pens were constructed to simulate a livestock crate. Two of these were covered and two were left uncovered. The cattle were randomly assigned to the pens and insects collected from each group using mechanical aspiration. Collections were made on eight nights over a four week period, commencing two hours before sunset and continuing at hourly intervals until three hours after sunset. The first collections were done in March and the second in June to accommodate different species of Culicoides dominant at different times of the year.

Collections were sorted to species and recently fed.

Results:

For *C. brevitarsis, C. oxystoma* and *C fulvus* there was no significant difference between the numbers of insects on covered and uncovered cattle. For *C. peregrinus* there were significantly fewer insects on catlle under covers. *C. actoni* results were unexpected and showed significantly more insects on cattle under covers. Since *C. actoni* is an effective vector for transmission of bluetongue viruses, covers cannot be used to protect cattle in areas where this species is found.

PROJECT: Wildlife Exotic Disease Preparedness Program (WEDPP) - Investigation of Possible Vectors of Japanese Encephalitis in Northern Animal Ecosystems

Project Officers: L. Melville, N. Hunt and S. Aumann

Location: A.L Rose Virology Laboratory, Berrimah Farm

Objective:

To identify major mosquito species feeding on pigs and test them for vector competence for Japanese Encephalitis.

Background:

In 1995 clinical and serological evidence was obtained of the presence of Japanese Encephalitis in the Torres Strait Islands. Since entry and establishment of Japanese Encephalitis will be dependent on competent vectors, possible vector species need to be identified and the level of competence established.

Method:

Mosquitoes are caught in a CO_2 trap, sorted to target species (*Cx. annulirostris* and *Cx. palpalis*) and held for two to three days. Surviving mosquitoes are fed overnight on stock Japanese Encephalitis virus in pig blood. Engorged mosquitoes are held for nine days and offered a one to two day-old suckling mouse to determine virus transmission. Mosquito and mouse infections are confirmed by PCR.

Results:

Approximately 215 mosquitoes were fed on infected pig blood. Of these, 90 surviving mosquitoes were individually fed on suckling mice. Mice were held for up to 12 days post feeding and their brains processed for virus isolation. For *Cx. annulirostris* transmission was confirmed in 2/54 mice and for *Cx.palpalis* in 7/36 mice.

PROJECT: Wildlife Exotic Disease Preparedness Program - Investigations of a New Virus of Horses in Animal Populations in the NT

Project Officers: L. Melville, S. Davis and Regional Animal Health staff

Location: A. L Rose Virology Laboratory, Berrimah Farm

Objectives:

To characterise a new virus isolated from two horses with encephalitis and determine the distribution in equine populations in the NT.

To investigate possible wildlife reserves for this virus.

Background:

In 1999 viruses were isolated from two horses with encephalitis in the Katherine region. These viruses appeared to be the same and could not be identified using a large panel of antisera to known viruses held both at Berrimah and the Australian Animal Health Laboratory. Basic information is required about these viruses to enable the identification and disease significance to be clarified.

Method:

The viruses will be further characterised at AAHL using molecular techniques and specific antisera will be produced at Berrimah to enable comparison with known viruses.

Surveys of equine populations in the NT will be carried out. Sera are tested in a neutralisation test to determine the sero-prevalence of this virus. Possible wildlife reservoirs will also be investigated by serology.

Results:

Sera collected between 1993 – 2002 were tested with the following results:

Equine	548 tested	59 positive
Bats	161 tested	72 positive
Pigs	549 tested	18 positive
Macropods	243 tested	9 positive
Cattle	300 tested	0 positive
Goats	58 tested	0 positive
Sheep	16 tested	0 positive

Antibody was restricted to the northern region of the NT, particularly the Darwin and Katherine areas. The highest level of antibody was found in bats.

HORTICULTURE

PROGRAM: Fruits

SUBPROGRAM: Mango

PROJECT: The Australian Mango Breeding Program

Project Officers: V. Kulkarni[1], I. Bally[2], R. Brettel[3], P. Johnson[4] and D. Hamilton[1]

Location: CPHRF, Southedge Qld, ARS Kununurra WA and CSIRO Darwin

[1] NT Department of Business' Industry and Resource Development
[2] Queensland Department of Primary Industries
[3] CSIRO
[4] WA Department of Agriculture

Objective:

The general objective of this program is to develop improved mango cultivars for the domestic and export markets through a hand-pollinated hybridisation program. It was recognised that each region might have some differing objectives but many would be common to all regions.

The specific aims of the project were initially set as follows:

- To develop hybrid cultivars with superior fruit quality and production characteristics that are suited to the various mango-growing regions in Australia.
- To generate a minimum of 50 individual hybrids for each parental combination over three years.
- To generate some quantifiable data on the inheritance of characters and the combining ability of specific mango cultivars.

The broad objectives of the program have been to develop cultivars with the following characteristics:

- *Dwarfness* – Reduced tree vigour and size is desirable, as “Kensington Pride” is over-vigorous at the expense of cropping in the hotter growing districts.
- *High productivity* – Mangoes are generally low producers when compared with other species such as avocado or stone fruit, and among mangoes, “Kensington Pride” is a low producer, on average producing between 5 to 10 tons per hectare.
- *Fruit size (400 g)*– The current domestic market has a preference for fruit in the range of 325 to 400 grams, making up trays of 18 to 20 fruit.
- *Fruit colour (good blush*) – Both Australian and export markets prefer fruit with high blush.
- *Retention of the KP flavour* – The Australian market and many export markets recognise the unique flavour of “Kensington Pride” as the cultivar’s greatest asset.

- *Reduced sap burn and post-harvest problems* – One of the greatest post-harvest fruit quality problems with "Kensington Pride" is skin browning and sap related injuries. Any reduction in this problem will significantly increase fruit quality.

- *Longer shelf life* – The shelf life of "Kensington Pride" is relatively short; prolonging storage time will improve access to export markets.

- *Reduced physiological disorders in the fruit* – Physiological disorders in the current varieties pose a major fruit quality problem that is hard to control using management techniques. Susceptibility to specific forms of disorder is cultivar related.

- *Early maturing* – Cultivars that produce fruit earlier than "Kensington Pride" have a distinct market advantage, especially in the Northern Territory.

- *Reduced susceptibility to disease* – In certain mango growing districts pre-harvest diseases such as bacterial black spot seriously limit the production of late cultivars. A reduction in susceptibility to this and other diseases will improve productivity and fruit quality.

Program of activities:

The Australian National Mango Breeding Program is a long-term project that has been divided into four phases of development

Phase 1, Hybridisation
This phase involved the generation of hybrids by using hand pollination methods described by Iyer (1994). The project aimed to generate a minimum of 50 individual hybrids for each parental combination over four years. The hybrid seeds were germinated at the centres where they were produced. Budwood was sent to Ayr to graft onto Kensington Pride stock and plant in the field at Southedge Research Station (Mareeba, Qld), for initial evaluation. The original hybrid seedlings were planted in the Northern Territory at the Coastal Plains Horticultural Research Farm, near Darwin. The hybridisation phase was completed in 1997.

Phase 2, Initial selection and characterisation
The second phase of the program involves the initial screening of hybrids for desirable types and collecting data on the specific characteristics for inheritance analysis. This screening is being done using the progeny planted at the two sites, Southedge and Coastal Plains. Southedge was chosen because of its cooler night temperatures and elevation, which stimulated the hybrids to flower at a younger age than in warmer areas. Detailed evaluation commenced in the 1999/2000 season and will continue until 2006. However, most trees will have been evaluated by 2003.

Phase 3, Detailed regional testing
The third phase of the program involves the planting of replicated trials in several agro-climatic regions to compare and evaluate the most desirable selections from the initial screening (Phase 2). Data obtained from these trials will be used to evaluate the commercial suitability of selections for the different growing regions in Australia and to prepare applications for Plant Breeder Rights.

The future of the Program was discussed in Darwin in November 2000, with all participating agencies. An agreement was reached in April 2001 on a set of core principles in respect of a pathway to commercialisation of potential new varieties coming out of the Program. These principles are set down in the following section. Negotiations are currently in progress for the selection of commercial partners to participate in the testing and marketing phases of the Program.

Phase 4, Market testing
The fourth phase of the Program consists of market testing and commercialisation of potential hybrids. This will involve testing in domestic and export markets of commercial quantities of fruit produced in grower-cooperator orchards. It is expected that contracting with grower cooperators for this purpose will commence in the second half of 2002. A possible first release of a commercial cultivar could happen as early as 2006.

Results during 2001-2002

Phase 2 – Hybrid evaluation and selection
Selection and culling of hybrids is being carried out at both planted locations (Mareeba and Darwin). The most promising selections are being propagated for testing in each of the various agro-climatic regions.

At Southedge Research Station, 655 hybrids were evaluated for fruit characteristics over the 2001/2002 season, thereby reaching a total of 1169 unique hybrids and parents evaluated since the beginning of the evaluation phase of the project in 1999. About 700 are still to be evaluated.

At the Coastal Plains Horticultural Research Farm, 258 hybrids were evaluated for fruit characteristics in November and December 2001, thereby reaching a total of 429 that have been evaluated at this site over two seasons. Most of the hybrids evaluated in the NT are represented in the set of hybrids that have produced fruit at Southedge.

At the Frank Wise Institute, Kununurra, 112 hybrids from the Western Australian crosses were evaluated for fruit characteristics over the 2001/2002 season. Out of those, the two most promising hybrids were 14061 and 14062.

At Southedge, 1244 hybrids were evaluated for tree characteristics such as tree vigour, canopy density and leaf fragrance.

The most promising hybrids have been selected from observations made at the three sites on the basis of a combination of characteristics. The selection has an initial bias towards fruit attributes for which the most information has been gathered, and the elite hybrids have been placed in two groups (A and B+) according to their inferred potential.

- Group A hybrids have a potential for commercial release and are included in replicated trials planted at Southedge, Coastal Plains and Kununurra. Trees from this group will be offered to grower-cooperators for regional evaluation.

- Group B+ hybrids have been selected for having a highly desirable combination of fruit characteristics. However, they require further evaluation to confirm their commercial potential. Trees in this group will be retained for further evaluation as single tree selections.

Replicated group A trial
A replicated planting was established of group A selections at Southedge Research Station in 2000. Hybrids included in this trial consist of current and past group A trees. The 2002 group A selections will be added to the trial in October 2003. The first crop from this trial is expected in January 2004.

A replicated planting of group A selections has also been established at Coastal Plains Horticultural Research Farm in the NT. Two grafted seedling trees of group A and two of group B+ selections have been planted at the CSIRO Plant Industry orchard at Berrimah. In addition, budwood from four group A and six group B+ selections has been top-worked to mature trees in the CSIRO orchard.

At the Frank Wise Institute, Kununurra, propagation of the group A hybrids commenced in 2001/2002.

To date, four of group A and several of group B+ selections have been successfully propagated.

Quarantined trees
Two trees of each group A selections are held in the glass house at Mareeba as clean quarantine trees free of the fungal disease scab (*Elsinoë mangiferae*). Limited quantities of budwood from these trees are now available and will be distributed according to the distribution plan

A flier prepared for general distribution is presented below.

Management coordinator report
The following is a brief summary of activities undertaken by the NMBP management coordinator over the past 12 months.

In collaboration with officers from the four Agencies that comprise NMBP, the background document was prepared for calling expressions of interest (EOI). This was advertised in a number of forums, with background documents either sent directly in response to initial enquiries or downloaded from the established web site.

Over 50 EOIs were subsequently received (15 from commercial agencies and 40 from growers). Commercial agency EOIs were assessed, and three of them were subsequently short-listed. Further information was sought.

After receiving supplementary information from the three short-listed commercial agencies, a full assessment was undertaken at the meeting of all NMBP partners in Mareeba in January 2002.

The Australian Fresh Mango Cooperative Ltd was chosen as the preferred commercial partner, and the management coordinator was asked to conduct further negotiations with it.

The National Mango Breeding Program

The National Mango Breeding Program was initiated in 1994 as a collaborative venture between the CSIRO, the Queensland Department of Primary Industries, the NT Department of Primary Industry and Fisheries, now the NT Department of Business, Industry and Resource Development, and Agriculture Western Australia. The principal objective was the development of new mango varieties for domestic and overseas markets.

The Australian mango industry is currently dominated by one variety - Kensington Pride - which has a high level of acceptance in the domestic market but suffers from several limitations such as low productivity, poor adaptation to tropical conditions, sap burn of fruit and a relatively short shelf-life.

The first phase of the program involved the production of approximately 1800 hybrid lines through controlled pollination. For the majority of crosses, Kensington Pride was used as one of the parents and hybridised to varieties considered as potential donors of desirable characteristics. For example, fruit colour (Irwin, Van Dyke, and Haden), shelf life (Tommy Atkins, Alphonso), and compact tree form (Julie, Willard). The hybrids were planted at two sites, one in the NT near Darwin and the other in North Queensland near Mareeba.

The broad objectives of the program have been to develop cultivars with the following characteristics:

- high productivity per tree;
- fruit size (400 g);
- fruit colour (good blush);
- retention of Kensington Pride flavour;
- reduced sap burn and post-harvest problems;
- long shelf life;
- reduced physiological disorders in the fruit;
- early maturing;
- reduced susceptibility to disease;
- compact tree form.

The first fruits for evaluation were produced in the 1999. Fruit characteristics were recorded for more than 1200 hybrids across three seasons. Forty lines have been identified as having a promising combination of characteristics, and the best of these have been propagated for further examination and market testing.

The next phase of the program entails the market testing and commercialisation of the most promising hybrids. This will involve producing and evaluating commercial quantities of fruit in grower-cooperator orchards and market testing fruit in domestic and export markets. Grower- cooperators will be chosen from all major Australian mango-growing areas. The first release of a commercial cultivar could happen as early as 2006.

PROJECT: Mango Flowering Project

Project Officers: **S. Blaikie[1], V. Kulkarni[2] and D. Hamilton[2]**

Location: Various mango properties in the Darwin and Katherine regions

[1] CSIRO Plant Industry, Darwin
[2] Northern Territory Department of Business Industry and Resource Development, Darwin

Objective:

Examine mango for the effect of flowering treatment (MFT) and paclobutrazol (PBZ) in commercial orchards in the Darwin, Daly River and Katherine regions.

Background:

Mango *(Mangifera indica* L.) production is a rapidly growing industry in tropical regions of northern Australia with annual production in the Northern Territory valued at around $35m. The industry is based predominantly on a single cultivar, Kensington Pride. In warm, humid conditions such as those in the Northern Territory this cultivar is prone to produce vegetative growth at the expense of flowers. As a consequence, yields are low and variable.

Erratic flowering and fruiting limits the productivity of Kensington Pride in the Northern Territory. A three-year project examined two flowering treatments, mango flowering treatment (MFT) and pacrobutrazol (PBZ) in commercial orchards in the Darwin, Daly River and Katherine regions of the NT.

Method:

Two flowering treatments were studied over a three-year period (1999-2001) on commercial orchards at nine locations around the Darwin, Daly River and Katherine mango growing regions. The age of trees varied between orchards and ranged from five to more than 10 years. The first treatment (MFT), relies on cutting a cincture through the bark around the trunk of the tree and applying a plant growth retardant, morphactin, by tying twine which has previously been soaked in a morphactin solution, into the cincture. MFT was applied once only in the first year. The second treatment, (PBZ), has been commercially available for some years. PBZ was applied each year. There were control (C) untreated trees at each site.

Records of flowering and yield were collected in each season. The level of flowering was expressed as a proportion (%) of the terminals on the canopy that was actively producing new floral growth. Yield was expressed as kg fruit/m^2 canopy surface area (csa) to allow a comparison between trees of different sizes.

Results:

There were large differences between locations and between years in the number of cool nights (T_{min} 18^oC or less) during the pre-flowering period (Table 1). Minimum temperatures of 18^oC or less are considered to be favourable for the induction of flowering in mango (Davenport and Nunez-Elisea 1997). All sites experienced abnormally cool weather in 1999 and the Darwin weather was cooler than normal in 2000. The temperatures in 2001 were close to average at all sites.

Table 1. The number of days with a minimum temperatures of 18^oC or less during the May-June pre-flowering period

Location	1999	2000	2001	long term mean
Darwin	15	14	5	7
Daly River	51	26	36	34
Katherine	57	43	44	42

The Bureau of Meteorology supplied the data.

Flowering
Figure 1 shows flowering data from site 1 as a typical example of responses observed at all sites.

1999
In 1999, there were large effects of MFT and PBZ treatments at most sites. In most cases trees in these treatments commenced flowering earlier and flowered more profusely than C trees. In fact, at some sites the treated trees achieved a maximum intensity of flowering that was up to twice that in C trees. The maximum intensity of flowering was generally in the range 60-80% for Darwin and Daly River sites and was above 80% for the Katherine sites.

2000
In 2000, the onset of flowering was similar in all treatments but there were large differences in the maximum intensity of flowering. At all sites the maximum intensity of flowering was highest in PBZ trees, reaching levels in excess of 90% at some sites. The effect of MFT was not as consistent as in 1999. At one site the maximum intensity of flowering in MFT was more than twice the level achieved in C trees but at other sites it was generally similar or marginally higher than in C.

2001
Compared with the previous two years, flowering in 2001 extended over a longer period than in the previous years. In particular, the trees in the Darwin region did not achieve maximal levels of flowering until much later in the season. Over all sites the maximum intensity of flowering was generally not achieved until late August – early September. As in the 2000 season, PBZ trees generally exhibited higher flowering than the other two treatments. The MFT and C treatments were similar.

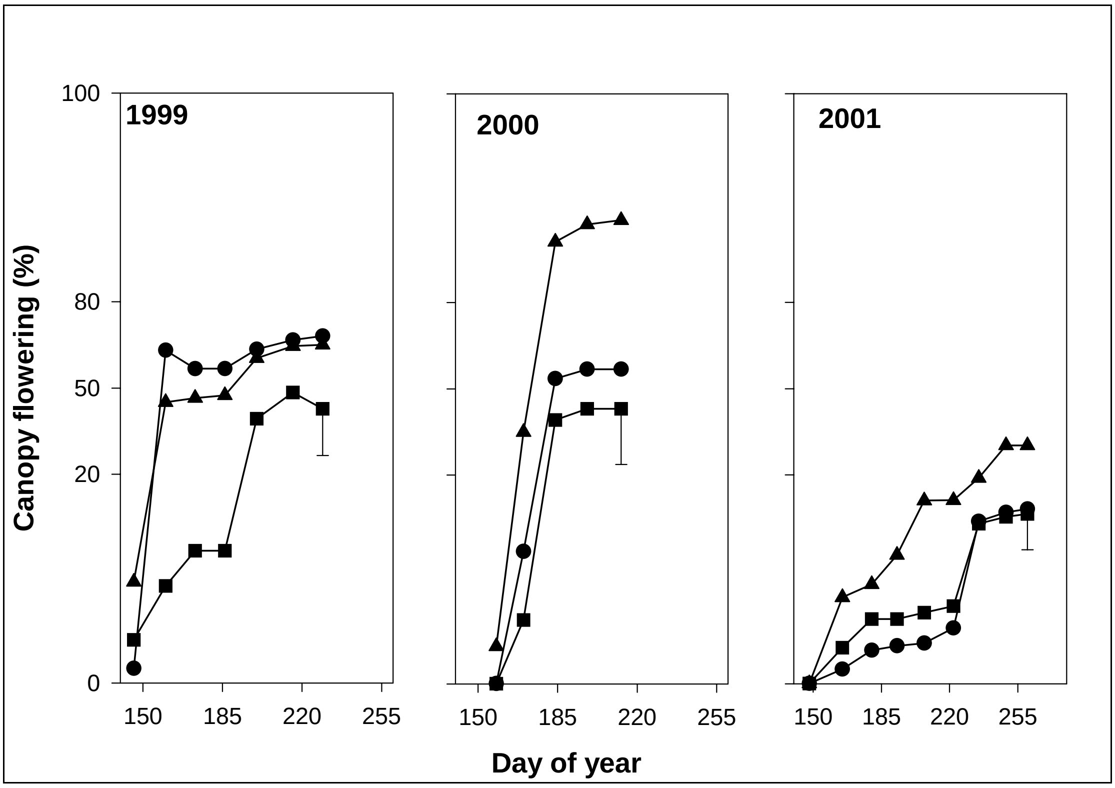

Figure 1. Patterns of floral development in each year during the experiment. Bars are lsd (P=0.05) between treatments in each year. Note different x-axis scales. Legend: square C, circle MFT, triangle PBZ.

Marketable fruit yield
Throughout the experiment yield ranged from 0 to 1.12 kg/m^2 csa (Table 2).

During 1999 the MFT treatments on five of the sites supported yields that were from almost twice (site 5) to many times (site 9) greater than in C. However at sites 1, 2, and 4 there was no benefit of MFT on yield. At site 8, the MFT caused a large reduction in yield. The PBZ treatment had large yield improvements at sites 2 and 6 and was intermediate to C and MFT at sites 7 and 9. The PBZ group of trees was no more productive than group C at sites 1, 3, 4, 5 and 8.

During 2000 the PBZ treatment significantly improved yields at sites 2, 4, 6, 7 and 8. Similar effects were achieved with the MFT except that it had no effect at site 2; and at site 8 the yield improvement was not as great as with PBZ.

In 2001 the consistently low yields of trees at the Darwin sites were notable, with yield ranging from 0 to a maximum of 0.30 kg/m^2 csa. The PBZ treatment significantly improved yield compared with C at all sites other than sites 4 and 5. In the M treated trees yield was little different to the C trees at all sites.

Table 2. Marketable yield (kg fruit/m^2 csa) at each site

		1999			**2000**			**2001**		
Location	**Site**	**C**	**M**	**P**	**C**	**M**	**P**	**C**	**M**	**P**
Darwin	1	0.50	0.58	0.53	0.53	0.49	0.77	0.02^{a}	0.00^{a}	0.19^{b}
	2	0.50^{a}	0.38^{a}	0.75^{b}	0.54^{a}	0.50^{a}	1.10^{b}	0.04^{a}	0.00^{b}	0.24^{c}
	3	0.30^{a}	0.90^{b}	0.63^{ab}	0.10	0.05	0.15	-	-	-
	4	0.68	0.73	0.54	0.15^{a}	0.31^{b}	0.37^{b}	0.30	0.27	0.27
Daly River	5	0.20^{a}	0.36^{b}	0.26^{ab}	-	-	-	0.69^{ab}	0.55^{a}	0.96^{b}
Katherine	6	0.12^{a}	0.35^{b}	0.72^{c}	0.18^{a}	0.92^{b}	1.11^{b}	0.39^{a}	0.63^{a}	1.12^{b}
	7	0.23^{a}	0.80^{b}	0.44^{c}	0.34^{a}	0.67^{b}	0.85^{b}	0.45^{a}	0.56^{a}	1.00^{b}
	8	0.77^{a}	0.28^{b}	0.72^{a}	0.15^{a}	0.57^{b}	0.85^{c}	0.54^{a}	0.60^{a}	0.84^{b}
	9	0.16^{a}	0.77^{b}	0.42^{c}	0.40	0.35	0.38	0.19^{a}	0.21^{a}	0.39^{b}

For each year, different letters denote significant differences (P=0.05) between treatments at each site.

Relationship between flowering and marketable yield

There was a positive relationship between the peak level of flowering and yield (Figure 2) although there was no consistent effect of season, treatment or site. Trees from all treatments, all sites and each of the three seasons of the study were represented in this range of points. Fruit yield increased as peak flowering increased, with up to 1.1 kg fruit/m^2 csa for flowering above 80%. High flowering was a prerequisite but not a guarantee of high fruit yield.

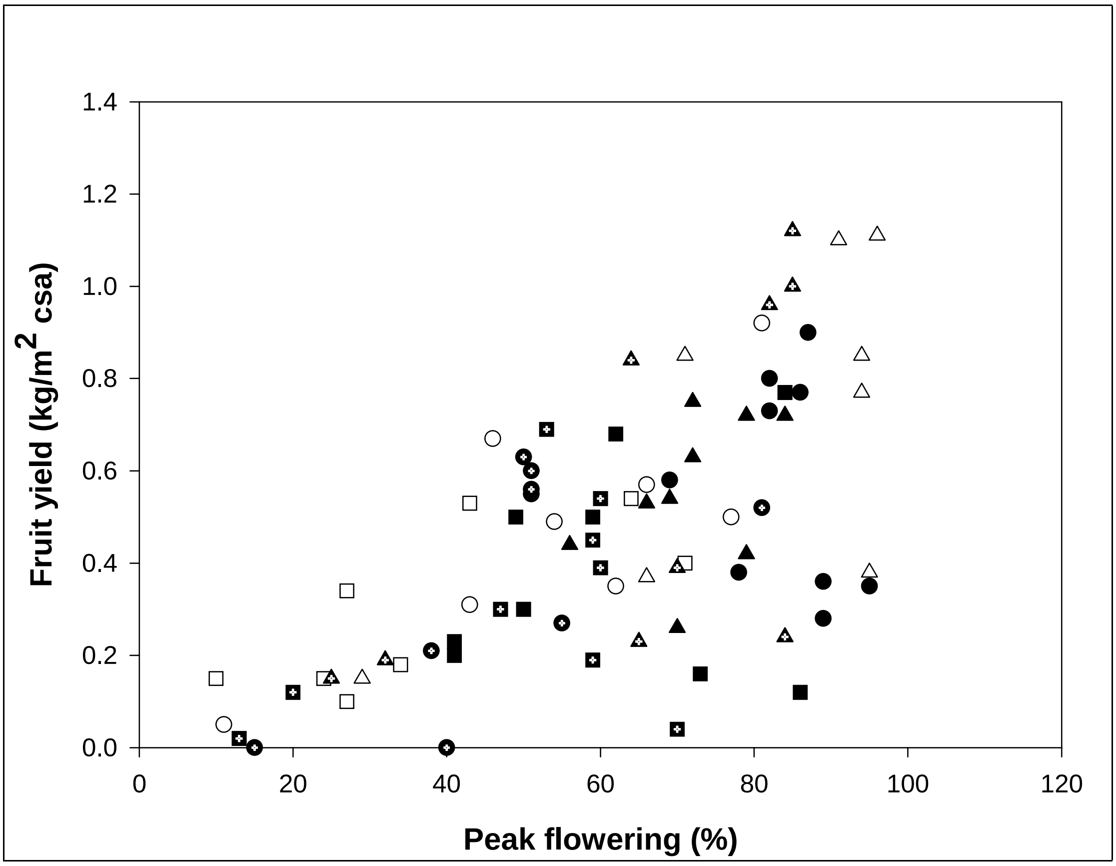

Figure 2. Relationship between yield (kg fruit/m^2 csa) of marketable fruit at harvest with peak level of flowering (%) recorded in July-August of each year. Legend: square C, circle MFT, triangle PBZ, solid 1999, hollow 2000, crossed 2001.

Modelling marketable yield

A range of variables measured at each site was used to model yield in 1999. This model (Eq. 1) explained 46 % of the variation in yield and was of the form:

y = a + trt + location + circumf + circumf.trt $\qquad R^2 = 0.46$, P=0.003 $\qquad$ Eq. 1

where y is yield of marketable fruit (kg fruit/m^2 csa), a is a constant, trt refers to flowering treatment C, MFT or PBZ, location refers to the geographic regions Darwin, Daly River or Katherine and circumf is the trunk circumference of the tree.

While trt and location were significant components of the model with P values of 0.019 and 0.017, respectively, circumf alone was not significant. However, the interaction term circumf.trt, with a P value of 0.007 was highly significant.

Predictions based on the model (Table 3) showed that averaged overall flowering treatments in 1999, produced 1.25 times more fruit in Darwin properties than in Katherine properties. The single site at Daly River was much less productive than all the others. The circumferences used for the predictions were arbitrarily chosen to reflect the range in trunk circumference that occurred across all sites in the experiment. These predictions, averaged over all locations, demonstrate that trees with relatively small trunk circumference are better suited to PBZ treatment and trees with large trunk circumference are best suited to MFT.

Table 3. Predictions of marketable yield (kg fruit/m^2 csa) in 1999 based on location and the interaction between trunk circumference and flowering treatment

Location				Trunk circumference (m)		
Darwin	**Daly River**	**Katherine**		**0.6**	**0.9**	**1.2**
0.60 (0.04)	0.28 (0.10)	0.49 (0.05)	**C**	0.45 (0.08)	0.37 (0.06)	0.28 (0.10)
			MFT	0.45 (0.07)	0.63 (0.06)	0.80 (0.10)
			PBZ	0.69 (0.07)	0.56 (0.06)	0.43 (0.10)

Standard errors of estimates are in parentheses

Other factors that were measured in the model but were not significant included soil texture, propagation source (whether graft or seedling), leaf chlorophyll content and canopy surface area. Leaf and soil nutrient levels were tested as surrogates for location but did not improve the model.

Discussion:

Flowering
These experiments have clearly demonstrated that both MFT and PBZ can be effective promoters of flowering in Kensington Pride mango in the Northern Territory (Figure 1). Furthermore, growers seeking to maximise flowering must implement some form of treatment to promote flowering because across all sites and years flowering of C trees rarely exceeded 60% and was often less.

The MFT had its greatest and most consistent effect on flowering intensity in the year following treatment but this effect diminished in subsequent years such that in the third year after treatment it offered no advantage compared with C and in two cases reduced flowering.

The PBZ treatment, which was applied each year, supported reasonably uniform and high levels of flowering at all sites (except site 3 in 2000) during the first two years. Flowering in the Darwin region (sites 1-4) in 2001 was less reliable, when the weather during May-June was much warmer than in previous years (Table 1). In this case PBZ trees did not reach high levels of flowering until much later in the year or did not reach high levels at all. However, although diminished in 2001 compared with the two previous years, flowering of PBZ was significantly better than C and MFT. At the Daly River and Katherine sites (sites 5-9) in 2001, where the weather was similar to previous years, the PBZ treatment was generally very effective in promoting early and intense flowering.

Cool weather during the pre-flowering period is well known to be an effective flowering inductant in mango (Davenport and Nunez Elisea 1997). This experiment provides evidence that PBZ and MFT can enhance this effect because treated trees (in year 1) attained higher levels of flowering than control trees despite the cool weather at all sites in 1999 and 2000 and at the Daly River and Katherine sites in 2001. However, for Darwin sites at least, these cool conditions during May and June are atypical (Table 1), with the MFT and PBZ treatments having been developed to overcome the limitations to flowering in warmer years such as occurred in the Darwin region in 2001.

Yield
As well as improving flowering, MFT and PBZ, were effective in improving yields. With few exceptions the yield of C trees was in the range 0-0.5 kg fruit/m^2 csa whereas some MFT and PBZ trees supported yields of 1 kg fruit/m^2 csa or more (Table 2). The size of the yield improvement with each treatment is in line with previous results (Leonardi et. al. 1999; Kulkarni 1988; Kulkarni and Hamilton 1996), with larger trees responding best to MFT and smaller trees being better suited to PBZ (Table 3). An additional benefit of these treatments is that they may be picked earlier in the season, when prices are often high. A feature of this experiment was that the sites were dispersed over a large geographic area that made it almost impossible to collect precise information on picking dates and quantities, although comments from growers indicated that where MFT and PBZ trees flowered earlier than C trees, they also matured earlier. Generally, the earlier the fruit, the higher the price for good quality fruit (Ngo and Owens 2002) so it is reasonable to attribute an additional ‘price premium’ to MFT and PBZ where these treatments resulted in earlier, high quality fruit. A further detailed comparison of harvest times and associated market prices will be required to fully quantify this benefit.

Although there were clear yield benefits arising from MFT and PBZ, both treatments need to be re-applied. The commercial recommendation is to re-apply PBZ each year but as yet there are no recommendations for

MFT. Early work (Leonardi et al. 1999) suggested that benefits of MFT could be achieved up to four years after a single application. In this experiment however, the largest benefits occurred in the first and second years after treatment with no benefit arising from the original application of MFT at any site in the third year. Future research should examine any effects on tree health and longevity on a wide range of sites, trees and re-treatment cycles before general recommendations on the likely best frequency of MFT can be made.

While these experiments have demonstrated significant improvements in the yield of MFT and PBZ trees compared with C, an interesting result has been the low yields that have been attained by the most productive trees. Yields of around 1.0 kg fruit/m^2 csa, approximately equivalent to two to three fruit/m^2 csa, indicate that many terminals did not carry fruit to maturity. Flowering data showed that commonly 60-80% or more of the terminals on MFT or PBZ treated trees produced flowers (Figure 1) so the low return of fruit per terminal represents an extreme inefficiency. Visual appraisal of the most productive trees in the district demonstrates that much higher yields – at least 3 kg fruit/m^2 csa - are possible. It remains unclear why none of the trees in this experiment approached this level of productivity. For the MFT trees in 1999 one explanation is that many fruit reached maturity at smaller than marketable size. Although these non-marketable fruit were not counted, visual estimates put their number at up to 30 % of the total fruit on the tree. In other treatments and in MFT trees in their second or later seasons after treatment, the number of non-marketable fruit at maturity was minor.

Limitations associated with carbohydrate storage and supply, the number of hermaphrodite flowers produced per panicle, pollination and fruit-set are possible contributors to the low productivity of trees in these experiments. Further studies are planned for coming seasons to investigate the possible role of pollinators, the pollination process itself and subsequent events during fruit filling (and fruit drop) until harvest.

One serious disadvantage with MFT was a significant reduction in fruit size in the year of application. A large proportion of fruit in most properties under MFT was unmarketable. MFT also induced severe chlorosis. Whether this was an effect mediated through the deprivation of roots and a negative feedback needs to be established.

Summary:

The key findings were:

- both MFT and PBZ were effective in supporting early and intense flowering in year one;
- the effectiveness of each treatment varied between sites;
- PBZ enhanced flowering in each year but its effectiveness was reduced in 2001 when pre-flowering temperatures were warm;
- the improved flowering with MFT and PBZ was generally reflected in higher yields with larger trees responding best to MFT and smaller trees being better suited to PBZ;
- the relationship between maximum flowering intensity and yield was weak;
- yield in all treatments was low ranging from 0-1.1 kg fruit/m^2 csa;
- the effectiveness of MFT declined over time such that in the third year treated trees were little different to controls; and
- MFT treatment led to chlorosis and significant reduction in fruit size in the year of application. Some trees in a few properties died because of the stress induced by the treatment. This aspect of the treatment is a major concern with MFT and needs to be investigated.

Growers need to use flowering treatments but achieving high levels of flowering alone is no guarantee of achieving high yield. It is likely that aspects of management between flowering and harvest are critical to achieving high rates of conversion of flowers to fruit. Current research is addressing this issue.

Acknowledgments:

The support of CSIRO Plant Industry, Northern Territory Department of Business, Industry and Resource Development, the cooperating growers and Horticulture Australia Limited is gratefully acknowledged. David Hamilton, Graeme Passmore and Gail Dunker provided technical assistance. Warren Muller provided advice on experimental design and data analysis. CropCare Australasia donated the paclobutrazol.

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PROJECT: Mango Sea Freight Trial

Project Officers: M. Gosbee, L. Thom and Opak, NTMIA

Location: Darwin, Guangzhou and Hong Kong

Objectives:

To extend the shelf life of mangoes and maintain the quality through the use of a controlled/modified atmosphere system during the transportation phase of the export process.

To determine the feasibility of sea freighting mangoes as an alternative to air freighting.

To build upon trial work conducted in Kununurra (WA) in 2000, implementing recommended solutions to identified problems and identifying any new problems and their cause.

Introduction:

Sea freighting of mangoes is an important facet in the long-term competitiveness of Australia's mango export industry. It provides an alternative transport option to airfreight and has the ability to move large quantities at any one time to distant markets that traditionally have been only supplied by air. Furthermore, sea freight should provide a lower landed cost to airfreight that could see Australia's export performance improved.

Northern Territory findings

The NT trials opted to use the Modified Atmosphere (MA) system due to the flexibility and relatively cheaper price that the technology offers. Two 20-foot reefer containers were used for the consignments to Guangzhou, Mainland China and Hong Kong.

The shipment to Guangzhou consisted solely of the mango variety Kensington Pride. The Hong Kong shipment also included the Irwin and R2E2 varieties. The trials showed that the MA system performed well to meet prescribed targets. Maintenance of controlled temperature was generally good during the voyage, with one exception. An increase in temperature during the Hong Kong to Guangzhou leg of the voyage was unsatisfactory.

The Guangzhou consignment also had water collecting in the container resulting in 20% loss due to wet and collapsed cartons. No such problem was encountered in the Hong Kong shipment.

Maintenance of fruit quality was also generally good with low level of disease and rots observed at the export markets. The single biggest problem with the two shipments was fruit softness. The probable cause was the MA, which artificially softened the fruit. A static trial conducted in Darwin (using standard cool storage) had fruit in a much firmer condition. In Asian markets, hard fruits are preferred. Prices received for the trial fruit were therefore lower than anticipated.

Other issues arising from the trial include:

- shortage of grade 1 standard fruit during shipment;
- access to europallets and suitable reefer containers in Darwin;
- high cost of sea freight relative to other Australian ports and airfreight from Darwin;
- transhipment delays in Singapore, resulting in overall increased sailing time; and
- Asian preference for hard fruit and the R2E2 variety.

The trial did however provide NT growers with invaluable knowledge and experience of the target markets and the sea freight exporting process. Indications are that the participating growers are keen to continue working on strategies to overcome current problems and/or find alternative strategies to access the target markets next growing season.

The industry may also explore air/sea options as a way to further refine these trials.

Recommendations:

The mango sea freight trials showed that sea freight from the NT and WA requires further refinement before it can become a viable transport option. This is because shipping costs are currently high relative to other Australian ports (this is particularly true for the NT). However, in part this is because no commercial volumes are currently transported by sea. Also, both the MA and CA technologies failed to maintain fruit quality required by target markets. The trials however, did resolve many of the problems encountered during the previous (2000) mango season.

Based on the results obtained during the trials it is recommended that:

- Further work is conducted on storage temperatures and atmosphere profiles in both the CA and MA systems. For example, conduct static trials to best determine the right mix of MA elements by length of journey to ensure the fruit can be delivered as required by the importer (i.e. hard), but without jeopardising the end quality in terms of increased presence of rots and diseases.

- Post-harvest handling and disease management problems identified in the trials be investigated and minimised to enhance fruit quality out-turn.

- Market visits be undertaken to gain better understanding of the different target market requirements.

- A coordinated approach by industry to promote and market the softer KP variety.

- A feasibility study is conducted to determine the combination of air and sea freight as an alternative transport option.

Conclusion:

This season the trials were able to address and solve a number of the problems identified during the 2000 trials. Problems such as sap burn, carton collapse, carton size, misshapen, poorly presented fruit and green skinned fruit were all adequately solved.

The Maersk CA container system appeared to resolve the problem with the loss of atmosphere encountered last season, but did not appear to have the expected impact on reducing fruit softening.

Problems with anthracnose were still apparent and severe in some lines of fruit but it appears that many of the growers have good to reasonable levels of control. The anthracnose issue needs to be further investigated in relation to orchard hygiene, sprinkler spray on leaves, especially for younger trees, the level of dead wood in orchards, canopy structure and efficacy of spray equipment. Post harvest handlings and applications of fungicide need to be examined to verify application time and chemical concentration.

The soft fruit problem will also require some further research to identify at what stage the fruit softens and the probable causes and solutions. This will include pre-conditioning the fruit and reducing storage temperature step-wise to 10ºC under a range of atmospheric conditions with periodic measurements of firmness during the trials to give a good indication of the stage when softness occurs.

In both trials during 2000 and this season, marketing came up as perhaps the number one issue. The reality in both trials was that much of the fruit was in extremely good condition, but importers were not geared to handling such a product.

Importers in Dubai and especially in London indicate that they see great potential for the KP variety in their markets.

It may now be advantageous to undertake a coordinated campaign working with one or two supermarkets where the sea-freighted fruit is placed in a prominent position on the supermarket shelves and a sampling promotion funded under a theme such as "ripe for tonight". The colour of the fruit is such that it has excellent visual appeal, instantly attracting customers. This then gives an excellent opportunity to the European customer and those who are used to harder fruit, to sample a small amount of the product and thus educate him or her, who is generally unfamiliar with mangoes.

As mentioned previously, a second trial is also very worthwhile to try to dispatch fruit from Australia that will arrive in the UK at the correct softness and eating quality.

PROJECT: Mango Crop Forecasting Evaluation 2001

Project Officers: G. Owens, C. Wicks and D. Hamilton

Location: Berrimah Farm, NTMIA

Objective:

To assist the mango industry to plan and coordinate the logistics and marketing for the mango season.

What was done in 2001?

The first flowering survey was sent out soon after the first flowering in July last year. The information provided gave a picture of the amount of flowering and its timing in the various growing areas around the Top End. There was a very good response to the survey from all areas. A second survey was done in early September. This information and the heat sum data were used to make a forecast for the mango season.

When all the information from the Darwin area was pooled, a clearer picture emerged. The prediction for the 2001 season is shown in Figure 1.

- A harvest peak for Darwin in early October that corresponded to the June flowering.
- Katherine peaking two weeks later due to the lower daily heat sum values.
- A gap in production starting in the last week of October.
- A second crop for Darwin starting in mid-November.

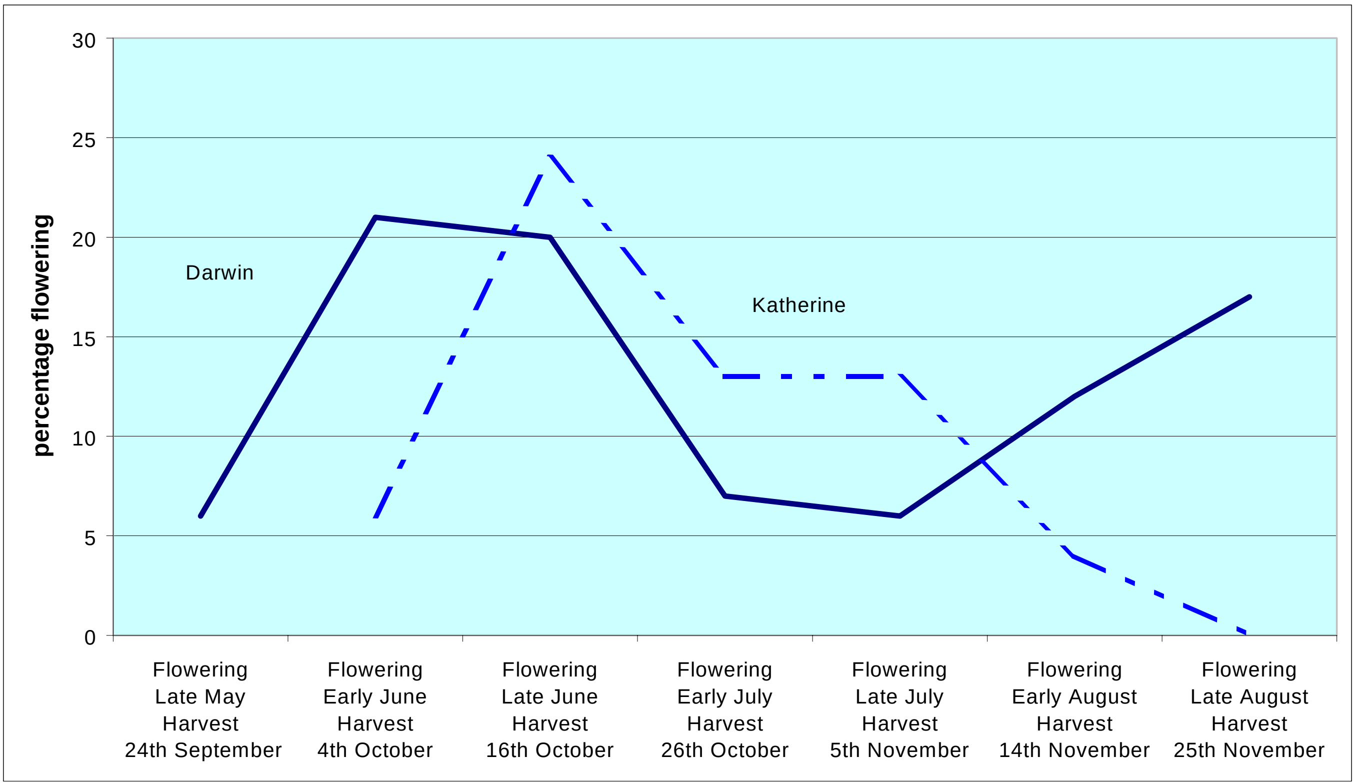

Figure 1. Darwin and Katherine flowering/harvest pattern

How close was the forecast?

The forecast was checked against the number of pallets of mangoes leaving Darwin during the season from a group of sheds and freight companies. Unfortunately there was no flow data available from Katherine.

There was a very close correlation between the Darwin 2001 season and the prediction for Darwin. The shape of the forecast line closely resembles the flow of mangoes out of Darwin.

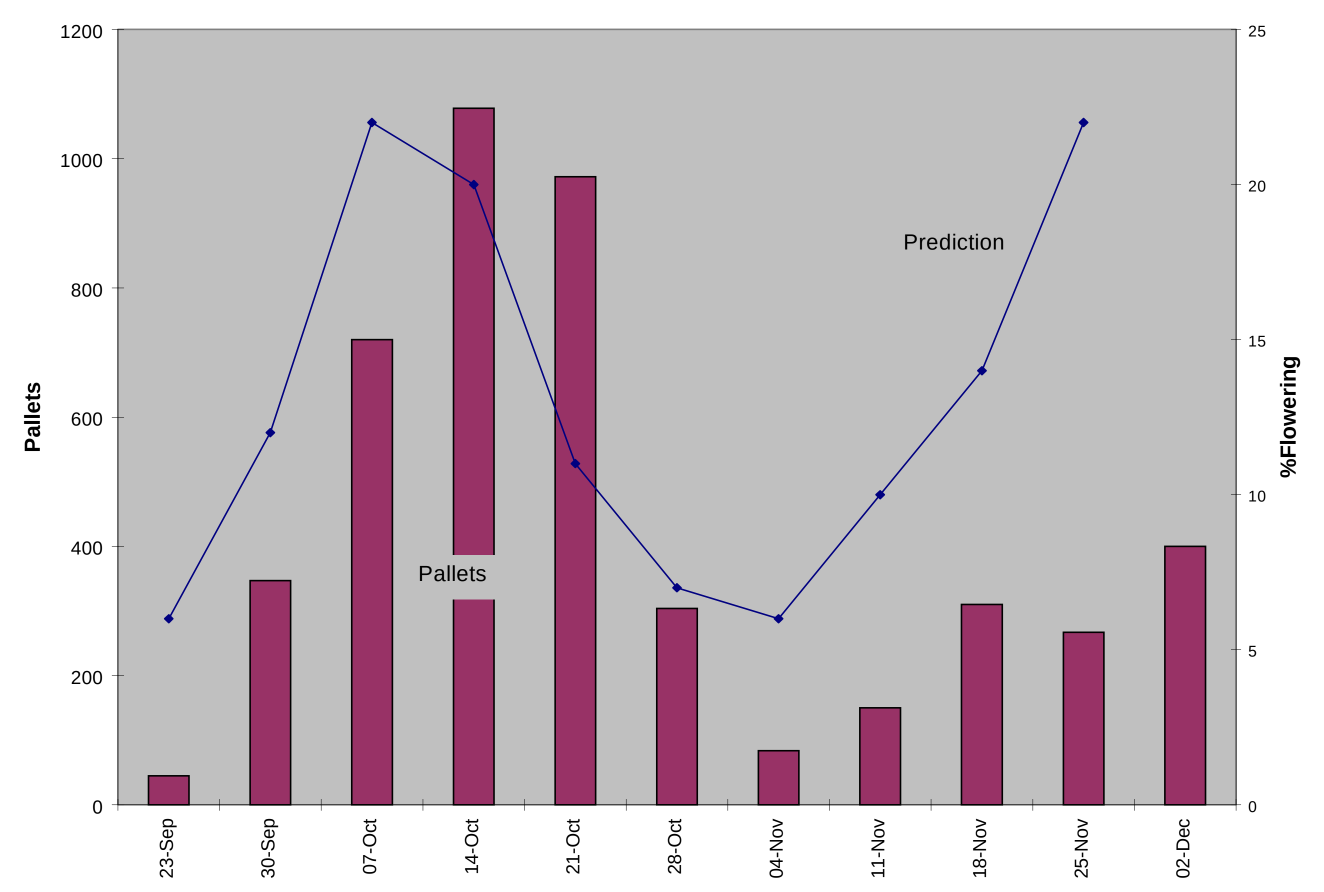

Figure 2. Darwin mango production prediction compared with actual flow in 2001

Some important points to note:

- There is about one week between harvest and getting fruit on the road. This is shown in Figure 2 by the time lag between predicted time and actual production.
- Figure 2 only refers to the survey sample. We expect to have a larger sample this season.
- Some Katherine fruit was packed from Darwin in October, which extended the first harvest peak.

What were the pre-season messages from the forecast?

- There was going to be a shortage of fruit in early and mid November. In fact one of the features of last season was that sheds and picking teams started and stopped through this period.
- Katherine’s predicted times fitted well into the gap in the Darwin season.
- Late fruit was going to be very late and would need protection with fungicide sprays.
- Early high prices would not last long with the peak of fruit coming on quite quickly.
- Quality fruit available in the gap period would command good prices. In fact, quality fruit maintained a good price throughout the season and there was a bigger price margin between good and poor fruit than in previous years.

Some points discussed by growers and packers during the season:

- With such a small first flowering compared with 2000, there was little need to rush the fruit onto the market; fruit had time to mature.
- There may have been some scope for a more spread out effort in mid October, than rushing masses of fruit onto an already well supplied market.
- Many growers made considered decisions to protect or not to protect their late fruit from anthracnose with fungicide sprays as they saw fit.
- Packers and pickers had a chance to access fruit from other regions or plan other activities, like maintenance, for the quiet time in the middle of the two fruit peaks.
- If similar information was available on the Queensland crop, better harvest decisions could have been made at the end of the season.
- This sort of information is invaluable to transport companies, market coordinators, agents and buyers. It needs to be used by the mango industry for the benefit of growers and packers.

How can it be done better in 2002?

There are a number of improvements already suggested for 2002, such as:

- More response to flowering surveys will increase the accuracy of the forecast timing.
- The forecast information can be distributed to participating growers more quickly.
- Mango flow data could be more complete, including from Katherine.
- Start the process of estimating crop volume predictions.
- Coordinate the storage and transport logistics of the 2002 season.
- Innovative use of the crop timing forecast in achieving a market advantage.

The value of crop forecasting depends on its accuracy, timeliness and the confidence people have in its predictions. After just one year it is too early to claim complete success. Last year's good match between prediction and crop timing needs to be repeated over the coming seasons. Crop volumes add a whole new dimension to the equation.

It will take the cooperation of all industry members to sharpen the focus on timing and get a handle on likely crop volumes. The big impact will come in the strategic use of the forecasts to coordinate the logistics and marketing of the NT mango crop.

SUBPROGRAM: Table Grapes

PROJECT: Develop Nutrition/Salt Management Guidelines for Table Grapes

Project Officers: **A. Nesbitt and S. Nagarajah**

Location: Alice Springs

Objective:

To validate or modify tentative petiole nutrient standards and identify nutrient problems.

Introduction:

Grapevines require adequate amounts of nutrients for growth and fruiting. Both nutrient deficiencies and excessive supplies of nutrients are harmful to vines. Measuring nutrient levels in petioles is a common diagnostic method used to establish if vines are affected by any nutrient problems. The results are then compared with a set of nutrient standards. The reliability of this method depends on whether an accurate set of nutrient standards has been used. The standards that are widely used in Australia are those published by Robinson et al. (1997). These standards have three limitations:

- They were established for own-rooted Sultana vines.
- They are valid only at flowering time and not for the whole season.
- The nitrogen standard is only for nitrate nitrogen and no standard is suggested for total nitrogen.

The nitrogen standard is important because nitrogen has a very strong influence on the productivity of vines, including fruit maturity and quality. Both nitrate-nitrogen and total nitrogen measurements have had drawbacks as diagnostic tools. Nitrate nitrogen is affected by other factors such as soil moisture levels and salinity. Total nitrogen is slow to respond to changes in soil nitrogen levels. Therefore, because of these drawbacks, care must be exercised in interpreting nitrogen analysis data (e.g. observations of vine vigour).

A nutrient-monitoring program was carried out in Mildura, Victoria to correct these limitations in own-rooted and Ramsey rootstock Sultana vines (Nagarajah 2000). This work:

- Established that the potassium and phosphorus standards for own-rooted and Ramsey Sultana vines were different.
- Established standards for the whole season.
- Established total nitrogen standards.

A similar nutrient monitoring program was carried out at Ti Tree over the last four seasons. The goal was to validate or modify Robinson et al. (1997) and Nagarajah (2000) nutrient standards for the cultivars grown at Ti Tree. The results were also used to identify nutrient problems in vineyards.

Method:

The monitoring program was carried out using mature vines from all the vineyards at Ti Tree. The cultivars and the number of vineyard sites from which petioles were collected for each cultivar are shown in Table 1.

Table 1. Cultivars and number of vineyard sites from which petioles were collected

Cultivar	Number of vineyard sites
Sultana	3
Flame Seedless	3
Menindee Seedless	3
Menindee/Sultana	3
Menindee/Schwarzmann	2
Menindee/Harmony	1
Red Globe/Ramsey	2
Total	**17**

Additional cultivars were included for the first time last season as part of a scion/rootstock evaluation project. However, as most of the vines from this survey are young, the nutrient results gained from these cultivars will be used as a guideline for future reference. This particular project may continue for another five years with nutrition as a major component.

The petioles were collected from opposite the cluster at monthly intervals from September until January. The samples were not collected after January because of degradation to the canopy due to grasshoppers and natural leaf senescence. Each petiole sample consisted of about 100 petioles and was collected at random along a vine row. All the nutrients in the petiole samples were measured.

Results:

Nutrient standards
Tentative nutrient standards for the whole season for grapevine cultivars grown at Ti Tree are presented in Appendix 1. These are standards developed for the current list of cultivars that have been sampled over the last four years. Additions or alterations to these standards may occur as information is obtained on new scion/rootstock combinations.

Nutrient problems
Nutrient analysis results were compared with the tentative nutrient standards, and nutrient problems were identified. Individual reports were prepared from the sampling done at flowering and were delivered to the relevant properties. Seasonal variations of the major nutrients and problems are highlighted below.

Macronutrients
Some results are presented in Figures 1 to 12 to show the macronutrient problems at Ti Tree. The results of own-rooted and rootstock vines are presented separately. The data has been averaged based on cultivar type across all vineyards to highlight differences in scion and rootstock combinations and not differences in vineyard management.

Nitrogen – Nitrogen levels were only high in Red Globe/Ramsey throughout the season (Figures 1 and 2). This was confirmed by the increased vigour seen in the vines. High levels of nitrogen and excessive vigour would have delayed maturity. All other cultivars showed good nitrogen levels throughout the season. However, checks on vine vigour should be made regularly.

Phosphorus – Phosphorus was adequate at flowering in all the cultivars (Figures 3 and 4). However, it became deficient later in the season particularly for Menindee/Harmony, Menindee/Sultana, Redglobe/Ramsey and Flame. Unlike other cultivars, the phosphorus level in Sultana did not decline rapidly after flowering and maintained adequate levels later in the season.

Potassium – Potassium was adequate for most cultivars both at flowering and during the rest of the season (Figures 5 and 6). Menindee/Sultana and Flame were exceptions. Flame had deficient levels of potassium throughout the season. This may have delayed maturity and colouring of the fruit.

Calcium – The only cultivar that showed adequate or near adequate levels of calcium throughout the season was Menindee/Sultana (Figures 7 and 8). Although calcium did rise steadily throughout the season, levels did not meet the increasing needs of the vine.

Sodium – Sodium toxicity was a problem in the latter part of the season in all own rooted cultivars (Figure 9). Grafted vines generally showed good sodium exclusion capacities, consistent with the characteristics of their respective rootstocks (Figure 10).

Chloride – Chloride toxicity was a problem in all own-rooted cultivars and Menindee/Sultana (Figures 11 and 12). Vines grafted to traditional rootstock varieties showed good chloride exclusion.

Micronutrients
Data on micronutrient problems at flowering is presented in Table 2.

Table 2. Percentage of petiole samples that had adequate, high or marginal/deficient levels of micronutrients at flowering

Nutrient	Adequate (%)	High (%)	Marginal/deficient (%)
Copper	94	Nil	6
Manganese	17.5	82.5	Nil
Zinc	6	17.5	2.5

Although there were a few problems with micronutrients such as marginal levels of zinc in some samples and high levels of manganese in most samples, the results of nutrition studies this year showed great improvements compared with previous years.

Iron was not included in Table 2 because the petiole iron level is not a reliable indicator of iron status. The best indicators of iron deficiency are symptoms in young leaves. In affected leaves, the blade is chlorotic, but the veins remain green. Iron deficiency symptoms were rare at Ti Tree.

Most of the relative micronutrient problems did not change later in the season. However, copper levels fell considerably in all vineyards to very low levels. This may have been due to the lack of copper sprays.

Discussion:

The most likely reasons for the high nitrogen levels in Red Globe/Ramsey were the high nitrogen levels in bore water and excessive irrigation of vines during spring. The problem was worsened in Red Globe/Ramsey by the extensive root system, which can absorb large amounts of nitrogen.

Vine nitrogen levels should be monitored periodically. Accurate scheduling of irrigations to ensure that the vine's water requirements are met without applying excessive amounts of water will reduce excess nitrogen and its harmful effects. In addition to petiole nitrogen levels, vine vigour is another indicator of vine nitrogen status - excessive vigour is an indicator of high nitrogen.

One or more of the following factors can induce phosphorus deficiency in vines at Ti Tree:

- Inadequate phosphorus fertiliser.
- Fixation of phosphorus in the soil after the application of fertiliser.
- High levels of chloride in the vine.

Phosphorus is the only macronutrient not supplied by bore water. Therefore, phosphorus fertiliser should be applied to vines. A recent trial indicated that significant reductions in soil (Olsen) phosphorus occurred following the application of phosphorus fertiliser. This problem is discussed in an accompanying report on a phosphorus response trial. High chloride levels in vines, caused by excess irrigation, reduce phosphorus uptake (Prior et al. 1992b). The harmful effects of phosphorus deficiency include a reduction in the fruiting capacity of vines (Skinner and Matthews 1989).

According to the petiole results potassium deficiency was not a problem at Ti Tree. However, vines at Ti Tree sometimes show potassium deficiency symptoms, such as the upward cupping of basal leaves. Two factors which can induce potassium deficiency are high sodium levels in the vine and/or a big crop load.

High sodium levels in vines caused by poor irrigation management, reduce potassium uptake (Mikirhara et al. 1999). A big crop load induces potassium deficiency because berries use large amounts of potassium during berry maturation. One of the harmful effects of potassium deficiency is delayed berry maturation.

Calcium deficiency is a problem at Ti Tree because low calcium levels in the soil. The problem is probably aggravated by excess vine vigour, which results in a dilution of the calcium content. It is not known whether high sodium levels in the vine reduce calcium uptake. Calcium deficiency cannot be easily corrected by applying foliar sprays or calcium fertilisers. A study carried out at Ti Tree showed that calcium sprays did not have a beneficial effect on the berries. The trial recorded the rate of water loss from grape clusters and berry sugar and acid levels. Some control measures that can be used to reduce calcium deficiency are:

- Controlling vine vigour.
- Not over-loading the vine with fruit.
- Using scion/rootstock combinations such as Menindee/Sultana, which have a good capacity to absorb calcium.

Calcium deficiency can reduce the shelf life of table grapes. Adequate calcium levels are required to reduce the rate of water loss and maintain bunch quality including the prevention of stem browning.

Sodium and chloride can be present in toxic levels in vines because bore water contains high levels of salt. Poor irrigation management aggravates the problem. Salt toxicity can affect vine health even before the appearance of salt toxicity symptoms in leaves (i.e. marginal leaf burn). Salt toxicity decreases growth, reduces yield and affects the quality of berries (Prior et al. 1992a and b, Walker 1994, Walker et al. 1997, and Stevens et al. 1999). The long-term solution to the problem may be to plant vines on salt-excluding rootstocks such Ramsey, Schwarzmann, Harmony, Teleki, Rugeri and Paulson.

Micronutrient deficiencies, such as zinc and copper, can occur at Ti Tree because the soil is alkaline with a pH of about 8. Zinc deficiency can reduce fruit-set and decrease the crop load (Cook 1966, Christensen and Jensen 1978). It can be corrected by applying zinc sprays about two weeks prior to flowering. Zinc fertilisers applied to the soil are unlikely to be effective because the high soil pH would fix zinc in the soil. In addition to alkaline pH, high rates of phosphorus fertiliser can induce zinc deficiency (Alexander and Woodham 1964). Copper deficiency can be corrected by using copper fungicides at least once early in the season. High levels of zinc and copper observed in the petioles were probably caused by repeated spray applications. Such high levels do not have any beneficial effect on the vines. Excessive use of zinc sprays can cause deformities in grape clusters. However, such deformities were not seen at Ti Tree. High manganese levels occur in vines at Ti Tree even without applying any foliar sprays. The reason for this is not known, but vines did not show any symptoms of manganese toxicity such as necrotic spots on older leaves, and chlorotic mottling near leaf tips and along leaf margins.

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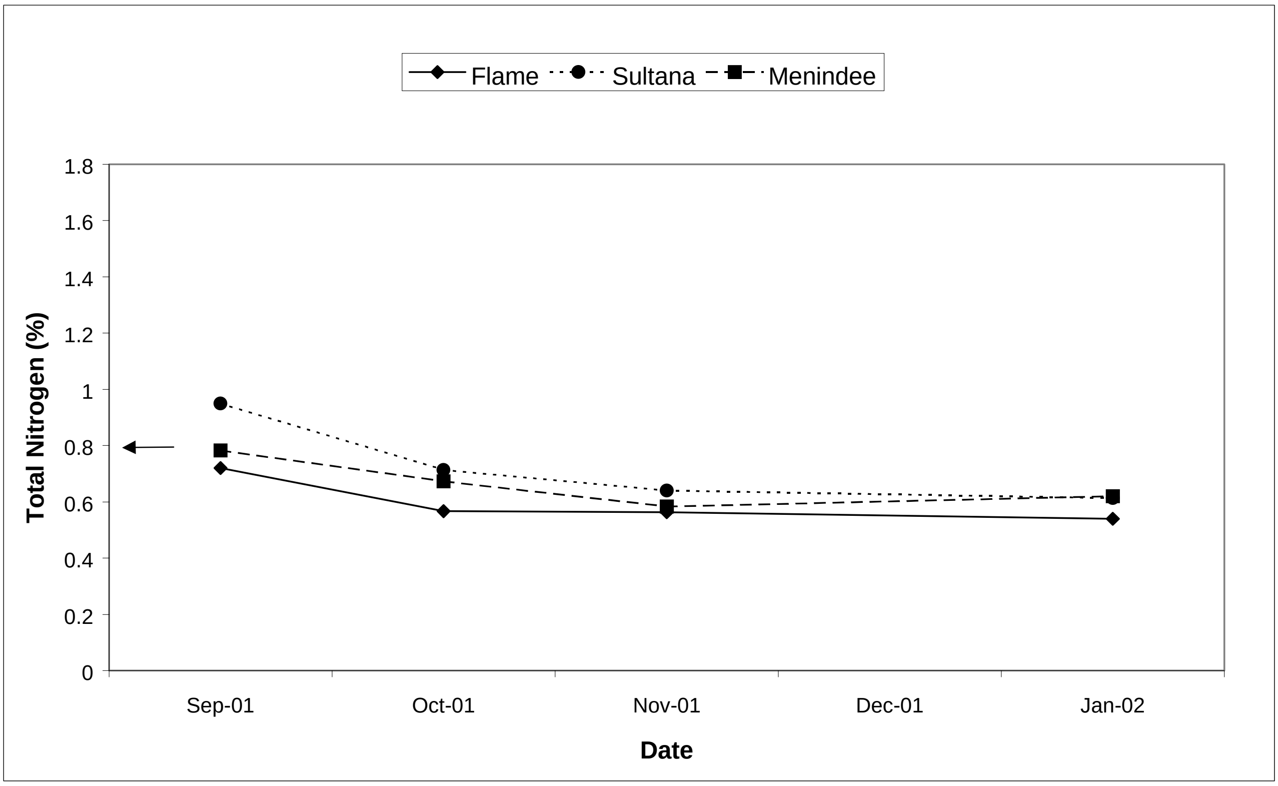

Figure 1. The changes in petiole nitrogen levels between September and January in own-rooted vines. The arrow indicates the adequate nitrogen level at flowering. The adequate level after October is about 0.5%.

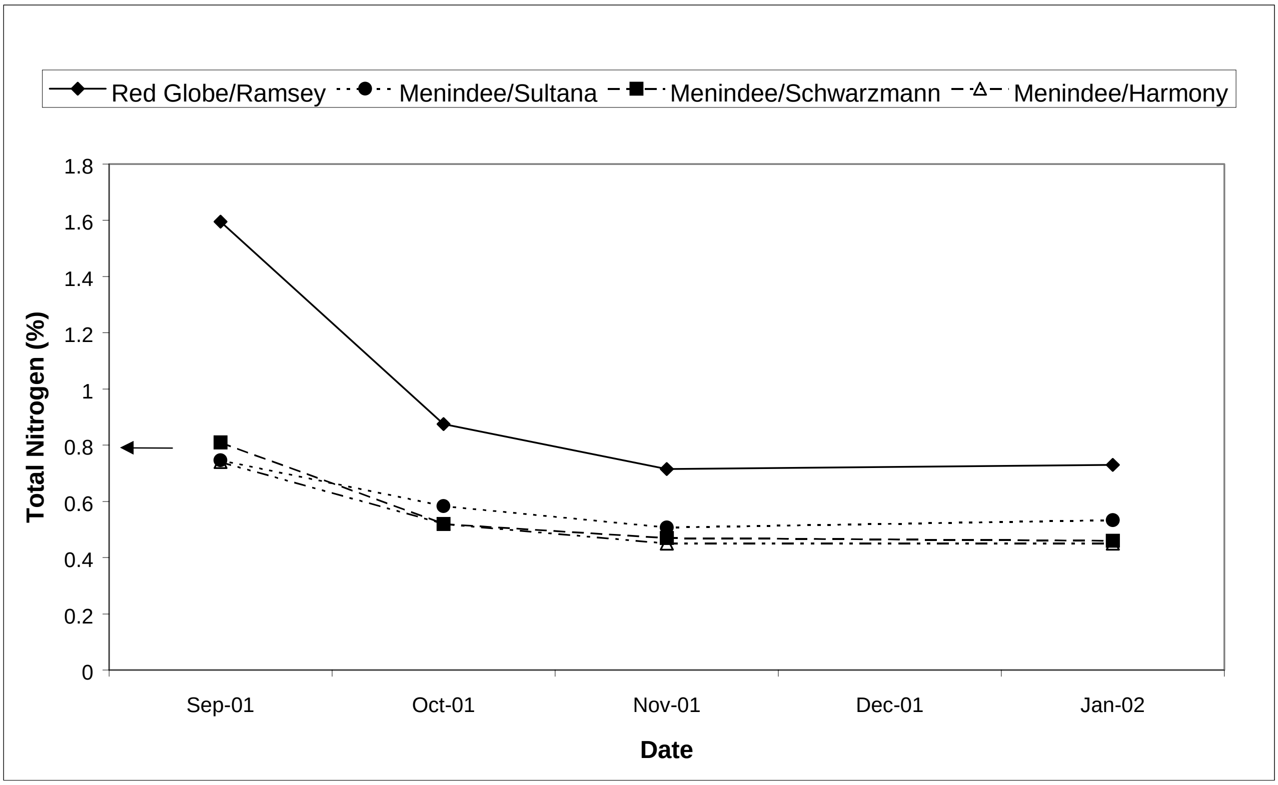

Figure 2. The changes in petiole nitrogen levels between September and January in grafted vines. The arrow indicates the adequate nitrogen level at flowering. The adequate level after October is about 0.5%.

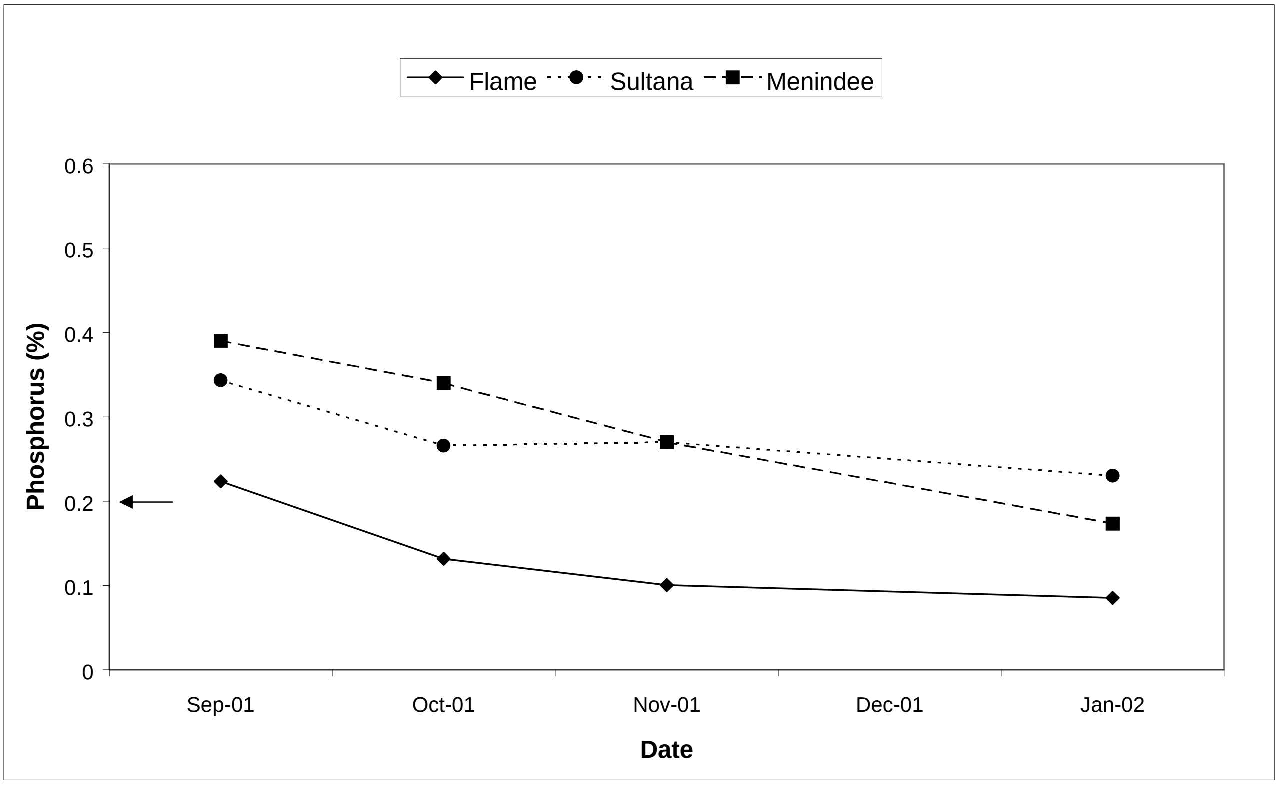

Figure 3. The changes in petiole phosphorus levels between September and January own-rooted vines. The arrow indicates the adequate phosphorus level at flowering. The adequate level after October is about 0.2.

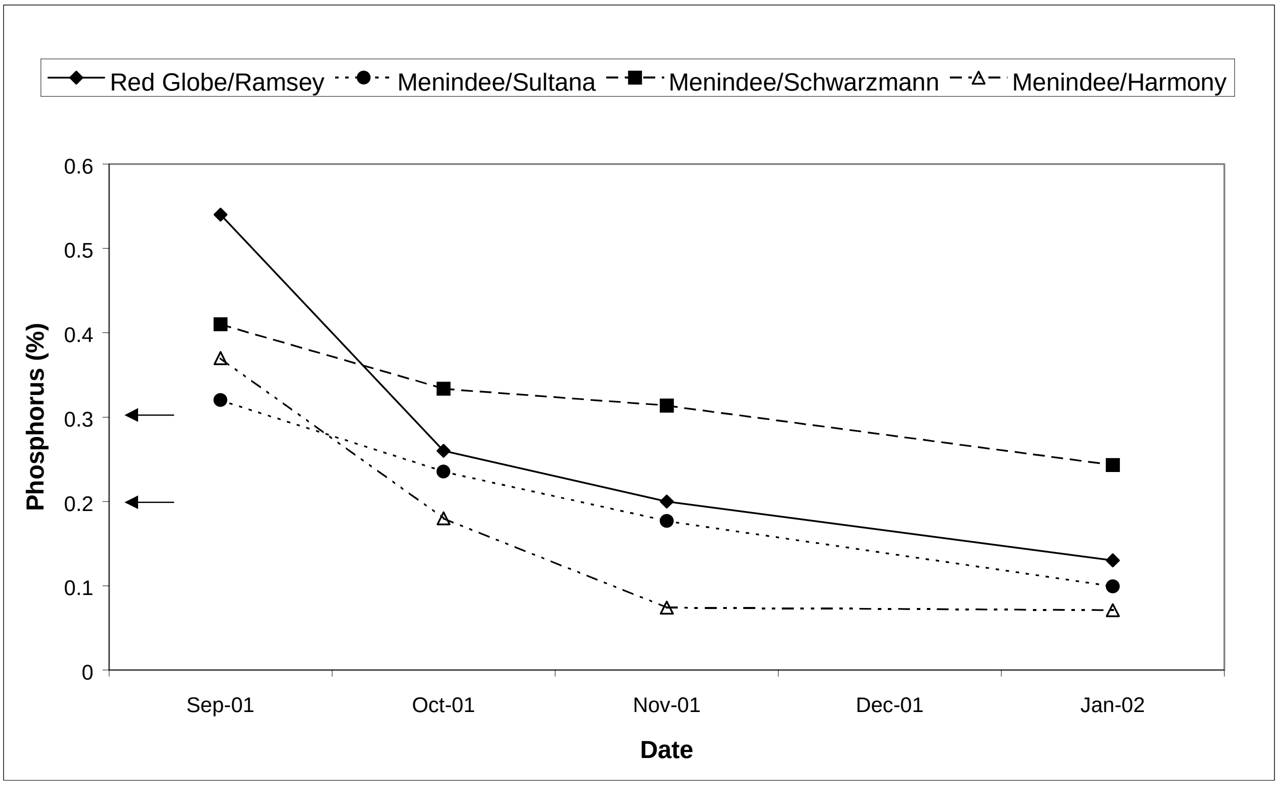

Figure 4. The changes in petiole phosphorus levels between September and January own-grafted vines. The arrow indicates the adequate phosphorus level at flowering (0.3-0.5% for Ramsey and Schwarzmann rootstocks and 0.2% for the others). The adequate level after October is about 0.3% for Ramsey and Schwarzmann rootstocks.

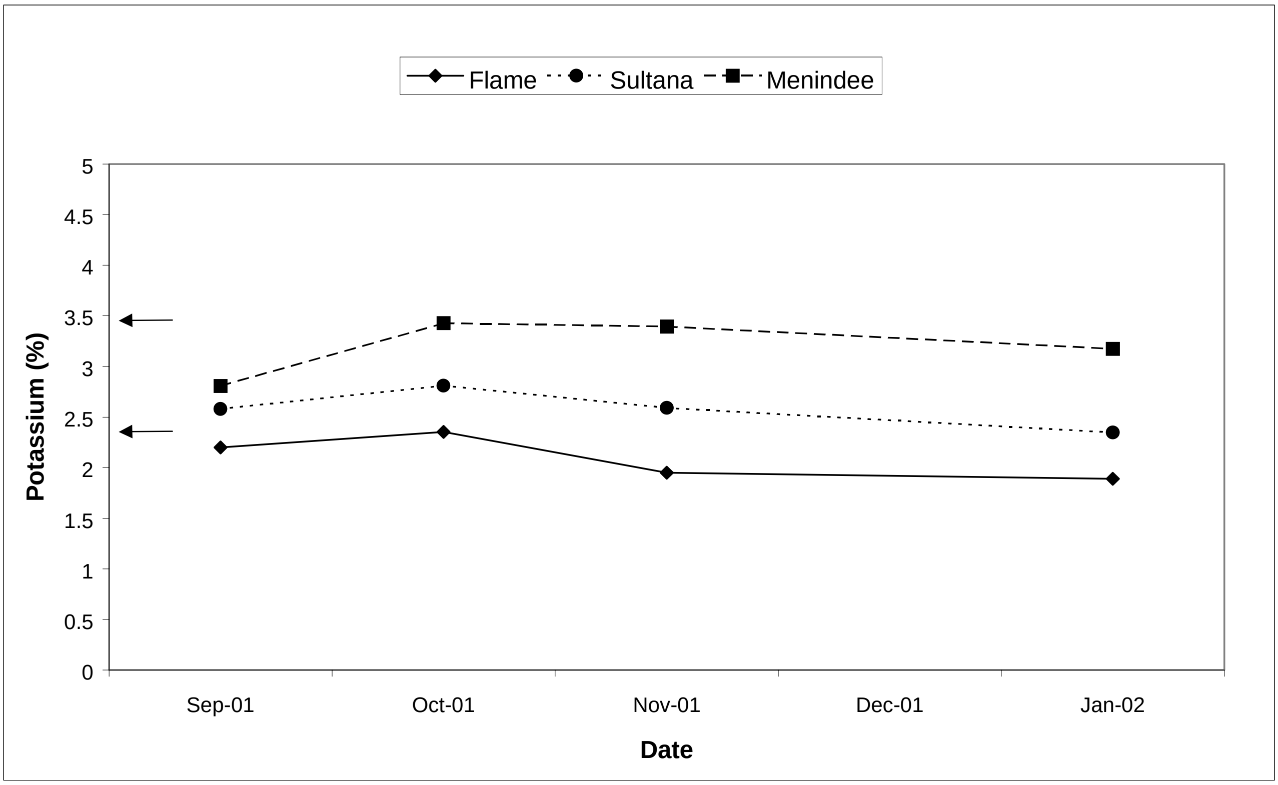

Figure 5. The changes in petiole potassium levels between September and January in own-rooted vines. The arrow indicates the adequate potassium level at flowering (3.5% for Menindee only). The adequate level after October is 1.5 - 2.0% (or 3-4% for Menindee).

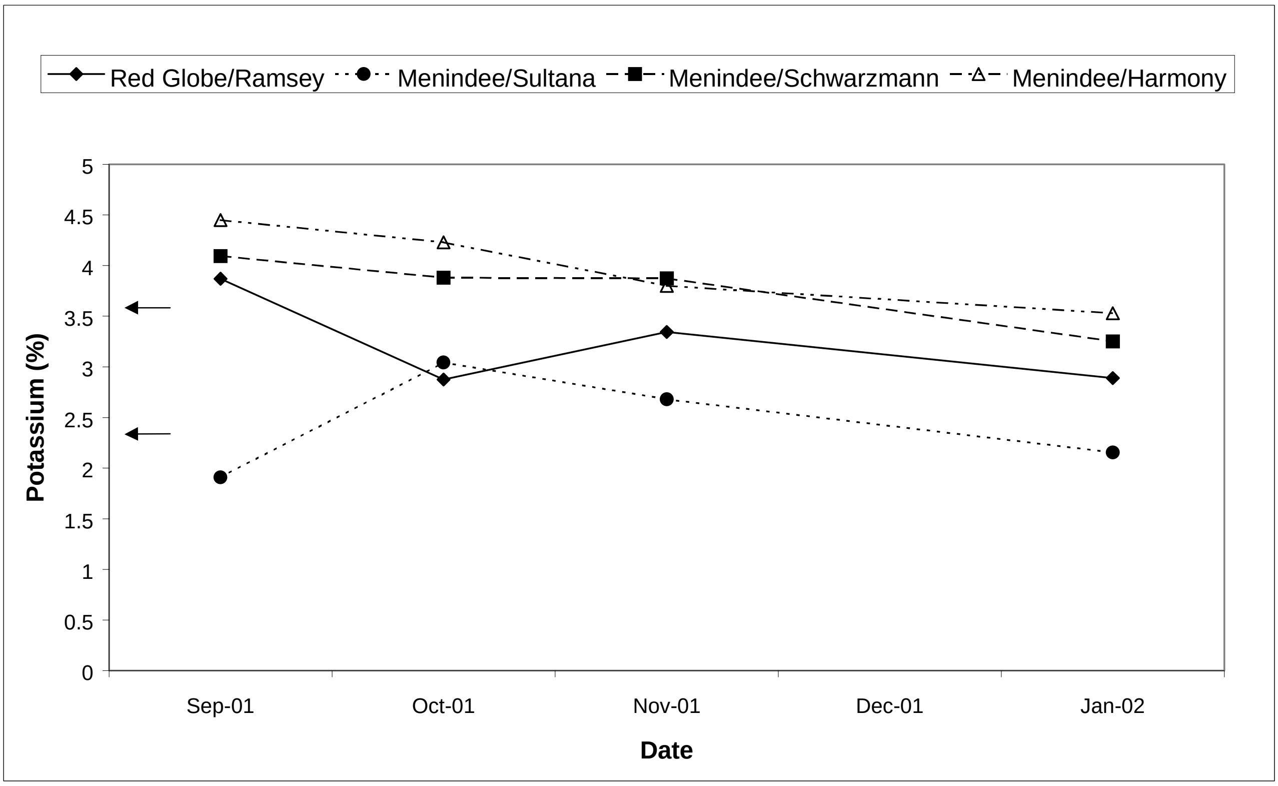

Figure 6. The changes in petiole potassium levels between September and January in grafted vines. The arrow indicates the adequate potassium level at flowering (3.5% for Ramsey and Schwarzmann rootstocks only). The adequate level after October is 1.5 - 2.0% (or 2.5-3% for Ramsey and Schwarzmann rootstocks).

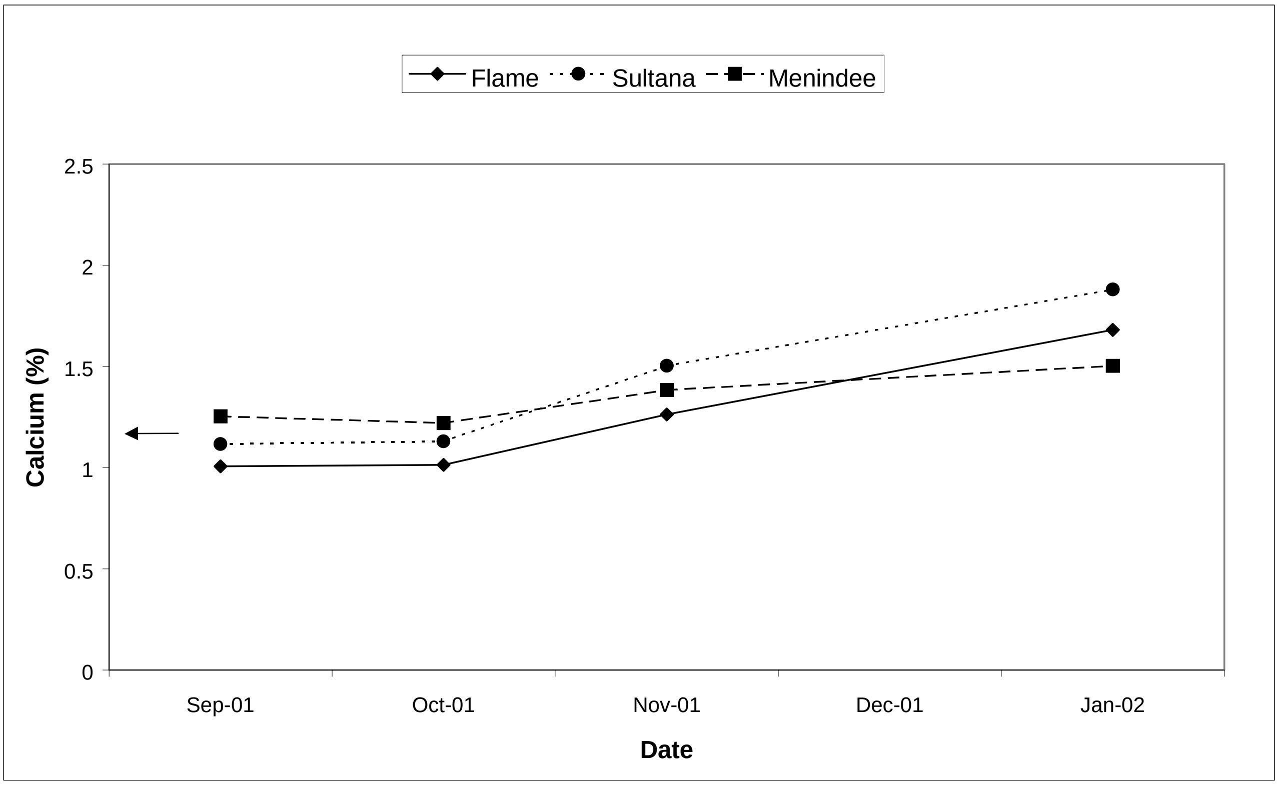

Figure 7. The changes in petiole calcium levels between September and January in own-rooted vines. The arrow indicates the adequate calcium level at flowering. Standards for the rest of the season are 1.5% for October, 2% for November, and 2.5% for January.

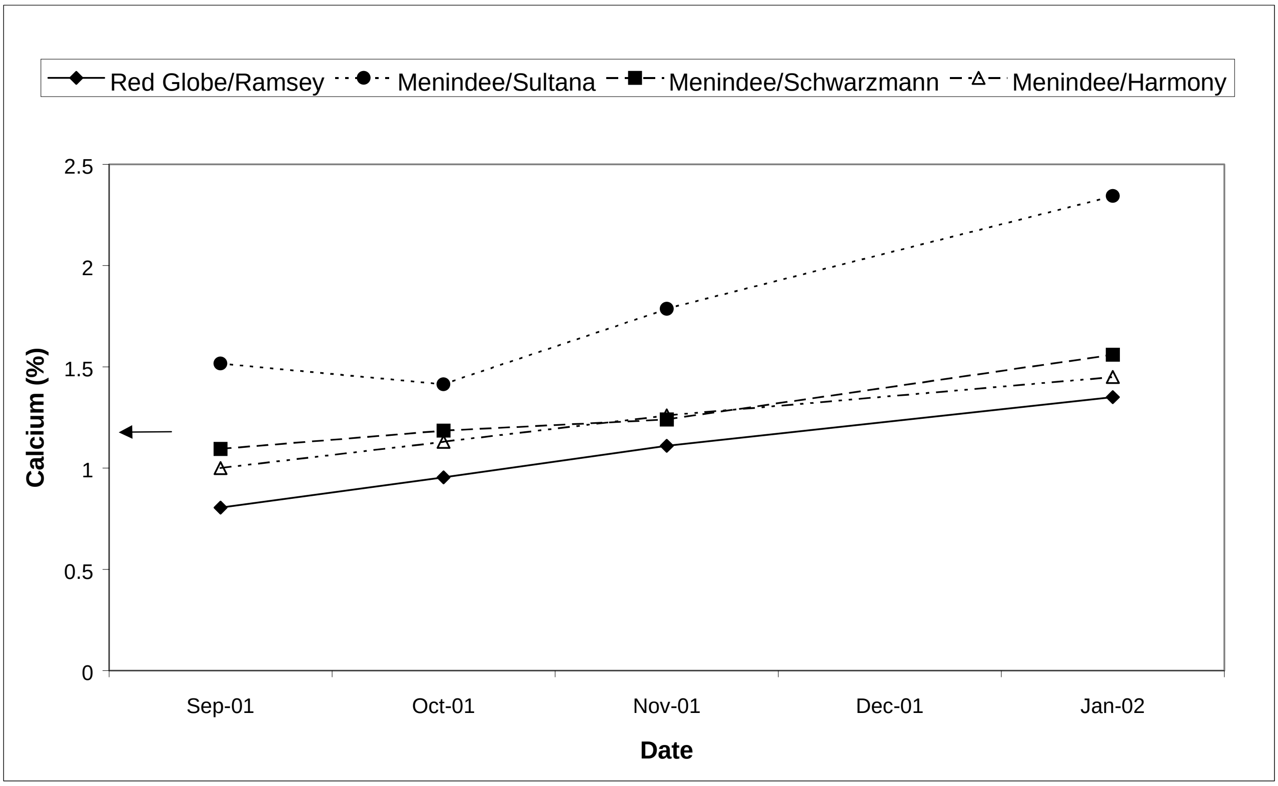

Figure 8. The changes in petiole calcium levels between September and January in grafted vines. The arrow indicates the adequate calcium level at flowering. Standards for the rest of the season are 1.5% for October, 2% for November, and 2.5% for January.

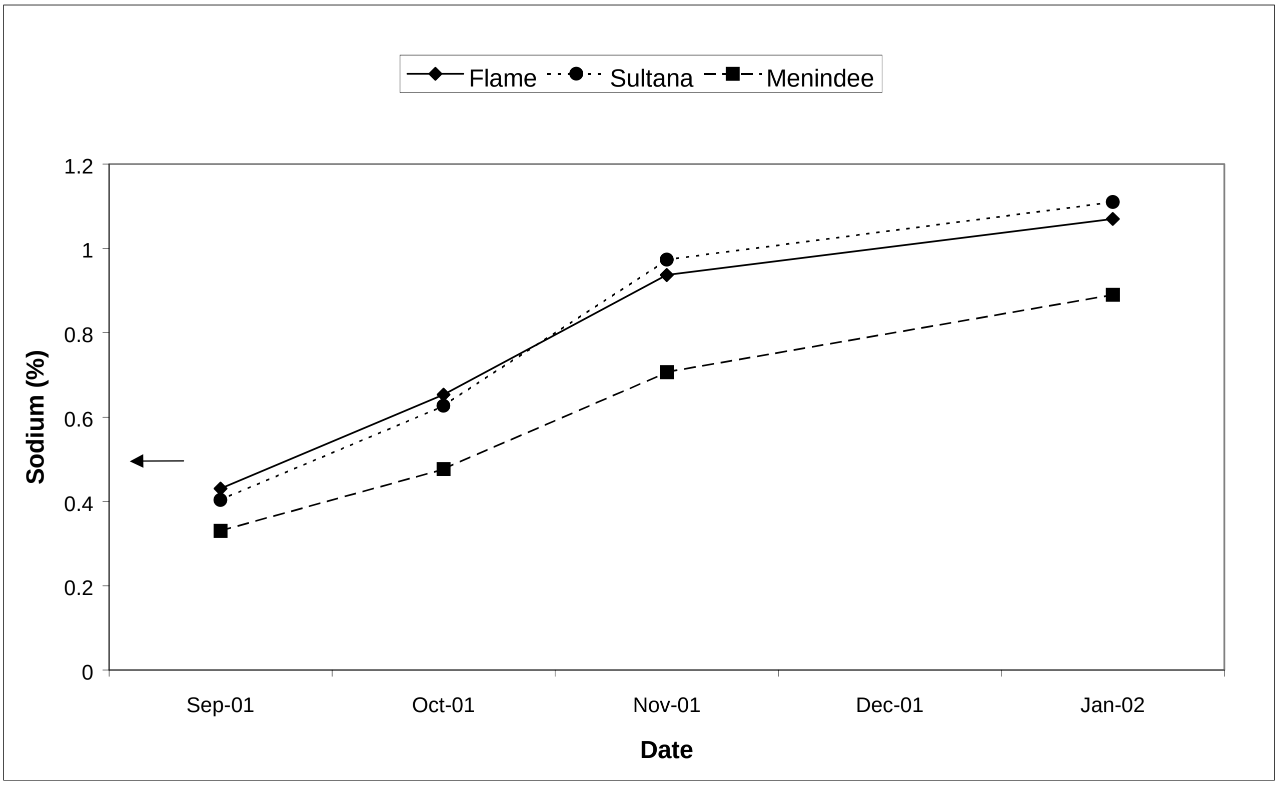

Figure 9. The changes in petiole sodium levels between September and January in own-rooted vines. The arrow indicates the toxic sodium level at flowering and rest of the season.

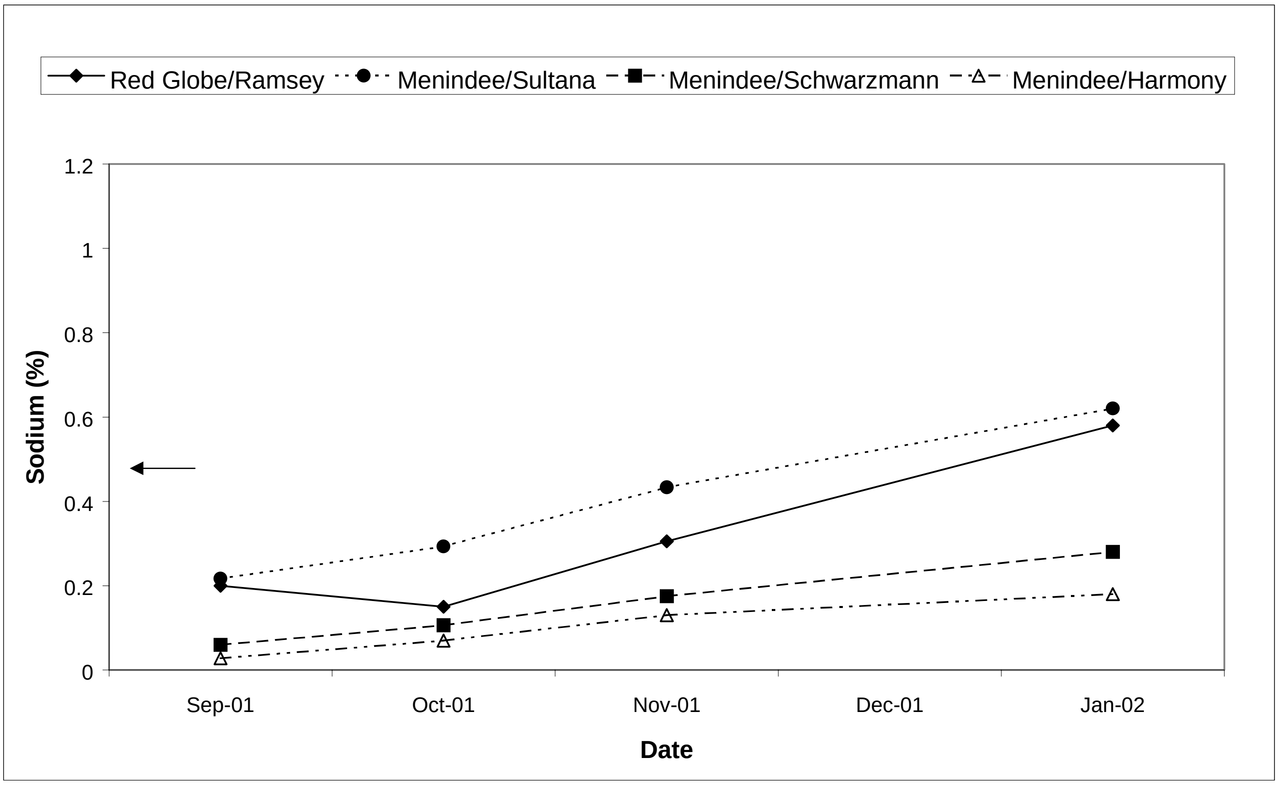

Figure 10. The changes in petiole sodium levels between September and January in grafted vines. The arrow indicates the toxic sodium level at flowering and rest of the season.

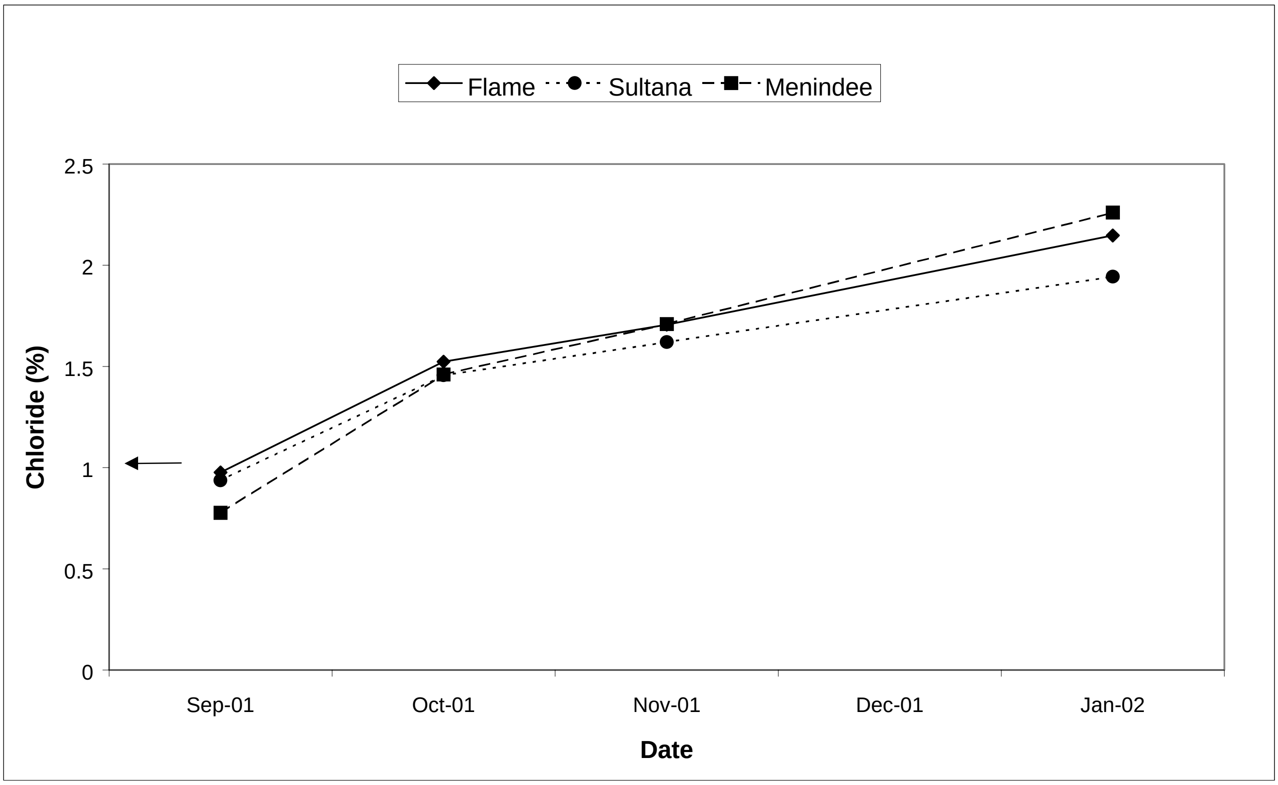

Figure 11. The changes in petiole chloride levels between September and January in own-rooted vines. The arrow indicates the toxic chloride level at flowering and rest of the season.

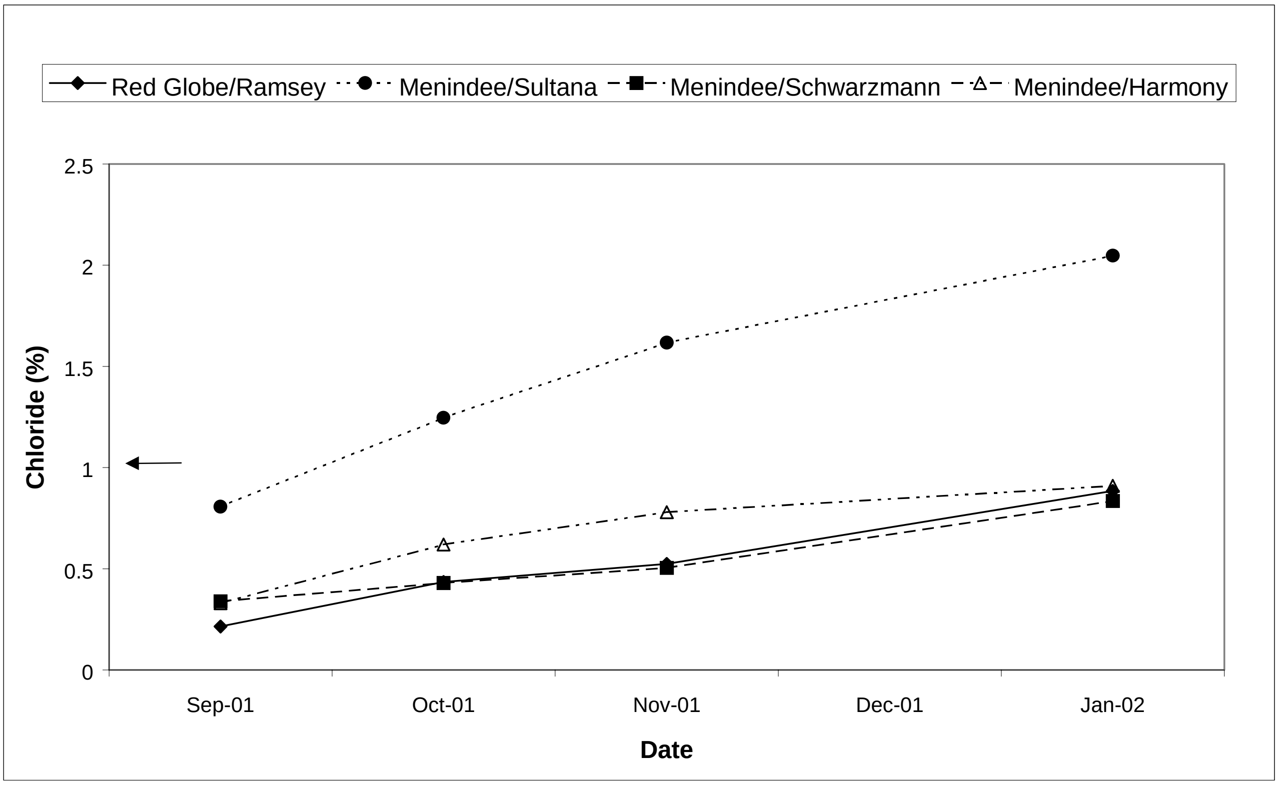

Figure 12. The changes in petiole chloride levels between September and January in own-rooted vines. The arrow indicates the toxic chloride level at flowering and rest of the season.

Appendix 1

Tentative Petiole Nutrient Standards for Grapevines
Tentative nutrient standards both at flowering (September) and for the October to January period are presented below. The tentative nutrient standards at flowering are those of Robinson et al. (1997), except for the standards used for nitrogen, phosphorus and potassium. These standards were established using the results of the nutrient monitoring program carried out over the last three seasons. The tentative standards will be revised, as more information becomes available, and other scion/rootstock combinations are included.

At flowering time (September)

Nutrient	Adequate Range
Nitrate nitrogen, mg/kg	500 - 1200
Total nitrogen, %	0.8 – 1.0
Phosphorus, %	0.2 - 0.3
Potassium, %	2.4 – 3.0
Calcium, %	1.2
Magnesium, %	>0.4
Sodium, %	>0.5 Toxic
Chloride, %	>1 – 1.5 Toxic
Iron, mg/kg	>30
Copper, mg/kg	6 – 11
Zinc, mg/kg	>26
Manganese, mg/kg	30 – 60
Boron, , mg/kg	35 - 70

Exceptions to the above standards are indicated below:

- Ramsey or Schwarzmann rootstock vines – Phosphorus 0.3 - 0.5%, potassium 3.6 - 4.5%.
- Menindee Seedless on own roots – Potassium - 3.5 - 4.5 %.

October to January

Nutrient	Own roots	Rootstocks*
Nitrogen %	0.5	0.5
Phosphorus %	0.2	0.3
Potassium** %	1.5 – 2.0	2.5 – 3

The rootstock standards are for vines on Ramsey or Schwarzmann vines and not for Menindee/Sultana. For Menindee/Sultana, the standards are the same as Sultana vines.

The exception to the above is the potassium standard for Menindee Seedless which is 3 – 4%.

	October	November	January
Calcium, %	>1.5	>2.0	>2.5
Magnesium, %	>0.5	>0.8	>1.2

*The standards for sodium and chloride at flowering are valid for the rest of the season.

PROJECT Develop Nutrition/Salt Management Guidelines for Table Grapes

Project Officers: **A. Nesbitt and S. Nagarajah**

Location: Alice Springs

Objective:

To determine the response of grapevines to potassium fertiliser.

Introduction:

Potassium is an essential nutrient for grapevines. The uptake of potassium by vines is far greater than any other nutrient, as large amounts of potassium are used during berry maturation. Potassium deficiency generally affects the sugaring and colouring of berries. Furthermore, it can affect bunches, making them small and tight, and berries may ripen unevenly. In order to prevent potassium deficiency, fertilisers are sometimes used in vineyards at Ti Tree. However, it is not known whether the fertiliser has any beneficial effect. Some of the benefits would be an increased potassium level in the petiole and soil and improved quality of berries. The question of benefit is being raised because of the following three reasons:

- Bore water supplies large amounts of potassium to the vine (about 260 kg/ha/annum). It is not known whether bore water can supply all the potassium requirements of vines.
- Vines do not absorb excess potassium when they already have adequate levels of the nutrient.
- High sodium levels in the vine can inhibit the uptake of potassium.

The trial was carried out to determine whether using potassium fertiliser had any beneficial effects at Ti Tree.

Method:

The trial was carried out in three vineyards using mature vines. Two vineyards had Menindee, Sultana and Flame. The third vineyard had only Menindee/Schwarzmann. The rates of potassium applied to the vines were 0, 20, 40 and 60 kg/ha, using potassium sulphate as the fertiliser. Each fertiliser treatment was applied to a group of five vines and each treatment was replicated four times along the vine row. Potassium fertiliser was applied to the vines on 8 August 2000 and again on the 7 August 2001. Assessments made in the trial and the dates on which they were carried out are shown below:

- Potassium levels in the petioles in all the cultivars in the three vineyards (20/10/00 and 6/12/00, and again on 3/10/01).
- Potassium level in the soil only in Menindee/Schwarzmann (20/9/00, 4/9/01 and 7/11/01).
- Sugar, acid and pH levels in the berry juice in Flame (1/11/01), in Menindee and Menindee/Schwarzmann (1/11/00 and 22/11/01) and Sultana (5/12/01).
- Potassium levels in the berry juice in Menindee and Menindee/Schwarzmann (1/11/00 and 22/11/01), and Sultana (5/12/01).

Results:

Petiole potassium
Petiole potassium levels in the three cultivars from one vineyard are shown in Table 1.

Table 1. The effect of potassium fertiliser on the potassium level in the petioles collected on 20/10/00 and 6/12/00 and again on 3/10/01 after fertiliser re-application

K, kg/ha	**Menindee (%)**			**Sultana (%)**			**Flame (%)**		
	20/10/00	6/12/00	3/10/01	20/10/00	6/12/00	3/10/01	20/10/00	6/12/00	3/10/01
0	5.24	4.89	3.40	3.08	2.50	2.98	3.12	2.06	3.18
20	5.32	4.85	3.48	3.40	2.63	3.27	2.99	2.27	3.24
40	5.05	4.67	3.49	3.13	2.31	3.28	3.15	2.34	3.26
60	5.24	4.89	3.37	3.30	2.54	3.10	3.32	2.03	3.25

Potassium fertiliser did not increase the potassium level in the petiole on any of the sampling dates. Similar results were observed in the other two vineyards.

Soil potassium
Soil potassium data is shown in Table 2.

Table 2. The effect of four levels of potassium fertiliser on the exchangeable potassium in the soil (cmol(+)/kg).

Potassium, kg/ha	**Soil potassium, cmol(+)/kg**		
	20/9/00	4/9/01	7/11/01
0	0.43	0.42	0.46
20	0.47	0.64	0.62
40	0.51	0.87	0.81
60	0.55	1.11	1.15
	LSD = 0.1	LSD = 0.42	LSD = 0.3

Fertiliser did not increase the potassium level in the soil in 2000, but on both sampling dates in 2001, soil potassium levels were raised significantly only after a repeated application of potassium greater than, or equal to, 40 kg/ha. However, as mentioned earlier, this did not result in any difference in the potassium levels in the petioles.

Berries
In 2000, potassium fertiliser did not have any effect on the brix, acid, pH values or potassium levels in the berry juice. Likewise in 2001, no relationship was found between berry weight, sugar/acid ratios, or potassium levels in the berries and the amount of potassium applied (Tables 3, 4 and 5).

Table 3. The effect of potassium fertiliser on berry weight

Potassium, kg/ha	**Berry weight (g)**			
	Menindee (1)	Menindee (2)	Men/Schwarzmann	Sultana
0	4.33	4.12	4.93	4.02
20	4.48	3.74	5.09	4.65
40	4.32	4.50	4.75	4.03
60	4.16	3.58	4.86	4.28

Table 4. The effect of potassium fertiliser on the sugar/acid ratio in the berry juice

Potassium, kg/ha	**Sugar(Brix^{o}C)/Acid Ratio**			
	Menindee (1)	Menindee (2)	Men/Schwarzmann	Sultana
0	19.88	14.65	13.97	16.53
20	20.44	13.06	13.12	17.04
40	20.54	17.11	13.11	16.56
60	19.25	16.17	15.01	16.58

Table 5. The effect of potassium fertiliser on the potassium level in the berry juice

Potassium, kg/ha	Potassium level (mg/L)			
	Menindee (1)	Menindee (2)	Men/Schwarzmann	Sultana
0	983	917	833	667
20	1067	1000	950	633
40	950	1000	900	567
60	1150	1017	950	750

Discussion:

The absence of any vine response to potassium fertiliser may be due to the vines already having adequate potassium levels, as vines will not take up additional potassium than is required. Another possibility is that high sodium in the vines inhibited potassium uptake. However, petiole sodium was below the toxic level in most trial sites at the time of sampling. Therefore, sodium would have played only a minor role in inhibiting the uptake of potassium.

A very useful outcome of the trial is that it has provided information on the adequate petiole potassium level at flowering in the four cultivars (Table 6). That is the petiole potassium level at which the addition of fertiliser would not have any beneficial effect. These values can be considered as the potassium standards for these cultivars at flowering. The sodium values in the petioles at flowering are also mentioned because sodium affects the uptake of potassium.

Table 6. The adequate level of potassium at flowering time in four vine cultivars

Nutrient	Menindee	Sultana	Flame	Menindee/Schwarzmann
Potassium, %	5.02 - 5.21	3.23 - 4.73	3.15 - 3.42	4.00
Sodium, %	0.16 - 0.22	0.26 - 0.68	0.59 - 0.80	0.12

In Menindee, Sultana and Flame, the standard is expressed as a range between two values. The two values are from the two vineyard sites where the trial was carried out. It is common practice to express nutrient standards as a range between two values. In Menindee/Schwarzmann, a single value is mentioned because the trial was carried out only in one vineyard.

Although soil exchangeable potassium levels were also measured in the three vineyards, petiole potassium level is a better indicator of potassium deficiency than the soil test. This is because potassium deficiency can occur in vines due to other factors even when the soil contains adequate potassium levels. These factors include inadequate irrigation and high sodium or nitrogen levels in the vines.

Reference:

Robinson, J. B., Treeby, M. T., and Stephenson, R. A. (1997). Fruits, vines and nuts. *In*: 'Plant analysis- an interpretation Manual". Eds. D. J. Reuter and J. B. Robinson (CSIRO Publishing: Melbourne) pp 347-389.

PROJECT Develop Nutrition/Salt Management Guidelines for Table Grapes

Project Officers: **A. Nesbitt and S. Nagarajah**

Location: Alice Springs

Objective:

To study the response of grapevines to phosphorus fertiliser

Introduction:

Phosphorus performs a number of functions in the plant as a major component of energy-carrying phosphate compounds, nucleic acids and several essential co-enzymes. Therefore, phosphorus is extremely important and plays an indispensable role in energy metabolism. Hence, phosphorus deficiencies should be avoided. Phosphorus deficiency can occur in vines at Ti Tree due to inadequate supply of phosphorus fertiliser and high chloride levels. High chloride reduces the phosphorus levels in vines even when the soil contains adequate phosphorus levels. Excess phosphorus must not be applied because it can lead to zinc deficiency. Foliar sprays of phosphorus are generally ineffective.

The second-year results of a phosphorus response trial are presented. It is a long-term trial and will continue for at least three years.

Method:

Mature Menindee/Sultana and Menindee were used in the trial in two vineyards. Three rates of super phosphate fertiliser were used: 0, 20 and 40 kg phosphorus/ha. These rates of fertiliser were applied to groups of five vines and each treatment was replicated four times. The fertiliser was first applied to the vines on 29/8/00. The same rates of fertiliser were reapplied to the same vines on 7/8/01. Petiole phosphorus levels were measured in petioles from samples collected on 3/10/01, 22/11/01 and 13/2/02 in both vineyards after reapplication. Soil phosphorus level was measured in both vineyards on 4/7/01 before reapplication and subsequently on 28/8/01, 7/11/01, and on 13/2/02 after re-application.

Results:

Petiole
Petiole phosphorus data is shown in Table 1.

Table 1. The effect of phosphorus fertiliser on petiole phosphorus levels (%).

Phosphorus, kg/ha	**Menindee/Sultana**			**Menindee**		
	3/10/01	22/11/01	13/2/02	3/10/01	22/11/01	13/2/02
0	0.41	0.24	0.13	0.39	0.23	0.09
20	0.41	0.27	0.15	0.45	0.31	0.15
40	0.43	0.29	0.18	0.43	0.31	0.14

In 2000, phosphorus fertiliser did not increase the phosphorus levels in petioles. Likewise in 2001, there was no significant relationship between petiole levels of phosphorus and the amount of fertiliser applied. However, given the nature of phosphorus uptake by vines and the characteristics of central Australian soil, vegetative responses to the addition of phosphorus may take up to five years to occur.

Soil
An average of the soil (Olsen) phosphorus data for both sites is presented in Figure 1.

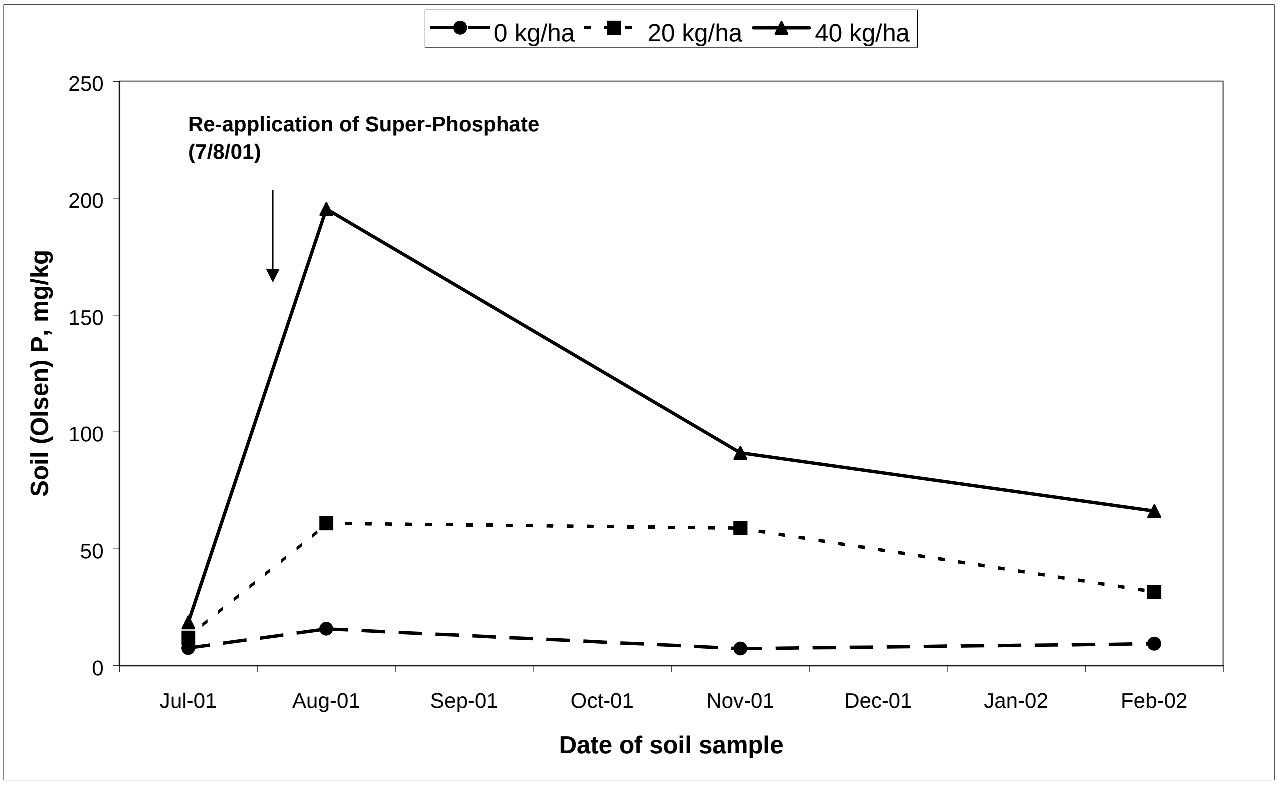

Figure 1. The effect of phosphorus fertiliser on soil (Olsen) phosphorus (mg/kg)

There was a significant increase in the (Olsen) phosphorus level in soil samples collected on 28/8/01 following the re-application of super phosphate. This was followed by a rapid decline over the next three-month period, particularly for the high phosphorus (40kg P/ha) treatment. A similar process was observed the previous season, where this rapid decline occurred over a two-month period. However, it should be noted that the figures presented indicate an extremely high amount of phosphorus in the soil. This represents values much greater than what is normally needed for plant growth. The high readings are indicative of raw fertiliser possibly being present in the soil samples. Therefore, February results give a much more accurate representation of the respective phosphorus levels.

Discussion:

Although there is the start of a trend for phosphorus to increase the petiole P level, this difference was not significant. This was not surprising because it takes about three to five years before vines show a response to phosphorus fertiliser.

The most significant observation made in the trial was a marked reduction in soil (Olsen) phosphorus between November and January. Similar results were observed last season. A number of factors can be responsible for this observation. These include uptake by the vines, fixation in the soil and leaching losses. In the alkaline soils at Ti Tree, iron oxides can play a significant role in the fixation of phosphorus (Holford 1977). In addition, excess irrigation and high temperatures at Ti Tree can accelerate the fixation of phosphorus (Burrow 1974). Two methods can be used to reduce the loss of phosphorus by fixation and leaching.

- Applying fertiliser only during the two periods when vines absorb phosphorus. The first ranging from after bud burst until veraison, and the second, less important, from about five weeks after harvest into the leaf fall period (Conradie 1981).

- Splitting the annual rate of phosphorus fertiliser application into smaller amounts.

It is not known if there are any differences in loss of phosphorus from the three types of phosphorus fertiliser used at Ti Tree: super phosphate, mono-ammonium phosphate and mono-potassium phosphate. A study was also carried out last season to obtain information on the fixation rates of four forms of phosphorus fertiliser.

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Holford, I. C. R. (1977). Soil properties related to phosphate buffering in calcareous soils. Communications in *Soil Science and Plant Analysis* **8,** 125-37.

Burrow, N. J. (1974). The slow reactions between soil and anions: 1. Effects of time, temperature and water content of a soil on the decrease in effectiveness of phosphate for plant growth. *Soil Science* **118,** 380-386.

PROJECT Develop Nutrition/Salt Management Guidelines for Table Grapes

Project Officers: **A. Nesbitt and S. Nagarajah**

Location: Alice Springs

Objective:

To quantify the decline of soil (Olsen) phosphorus

Introduction:

A grapevine fertiliser response trial using super phosphate has been carried out over the last two years. While this trial may need to continue for at least one more season, an important finding so far has been the rapid decline of phosphorus in the soil following its application. The decline of phosphorus in the soil may be due to a number of factors including; pH of the soil; soil temperature; rainfall and leaching; iron and calcium contents; and the form in which the phosphorus is applied. While most of these characteristics remain consistent across the grape growing region, it is not known which, if any, of the forms of phosphorus fertilisers is more likely to be lost or fixed more readily than any other. Therefore a new trial was carried for one season to assess the rate of decline of four different forms of phosphorus fertiliser in a vineyard environment.

Method:

Four types of phosphorus fertiliser were applied in a replicated trial on Menindee/Sultana in one vineyard. The fertilisers included super phosphate, triple super, mono-ammonium phosphate (MAP), and mono-potassium phosphate (MKP). All forms of fertiliser were applied at a rate of 40 kg P/ha on 28/8/01. Soil samples were collected to only a depth of 30 cm on a monthly basis for the first three months and then twice more every second month. Samples were analysed for phosphorus content using both Colwell and Olsen methods.

Results:

Results from the five sampling dates are presented in Figure 1. Although there appears to be a difference in initial levels of phosphorus, this is most likely due to a residual effect from raw fertiliser entering the sample. As the first sampling was done soon after fertiliser application, it is highly possible that undissolved fertiliser was still present. In fact, even towards the end of the trial, six months after the application of fertiliser, both super phosphate and triple super could still be seen in granulated form.

From the results gathered, it is inconclusive as to which fertiliser is more readily fixed in the soil. However, there does seem to be a trend for super phosphate and triple super to maintain higher levels for longer periods, possibly due to their lower solubility.

Both the Colwell and Olsen method results showed similar trends. A relationship between these two tests is being established for Ti Tree soils.

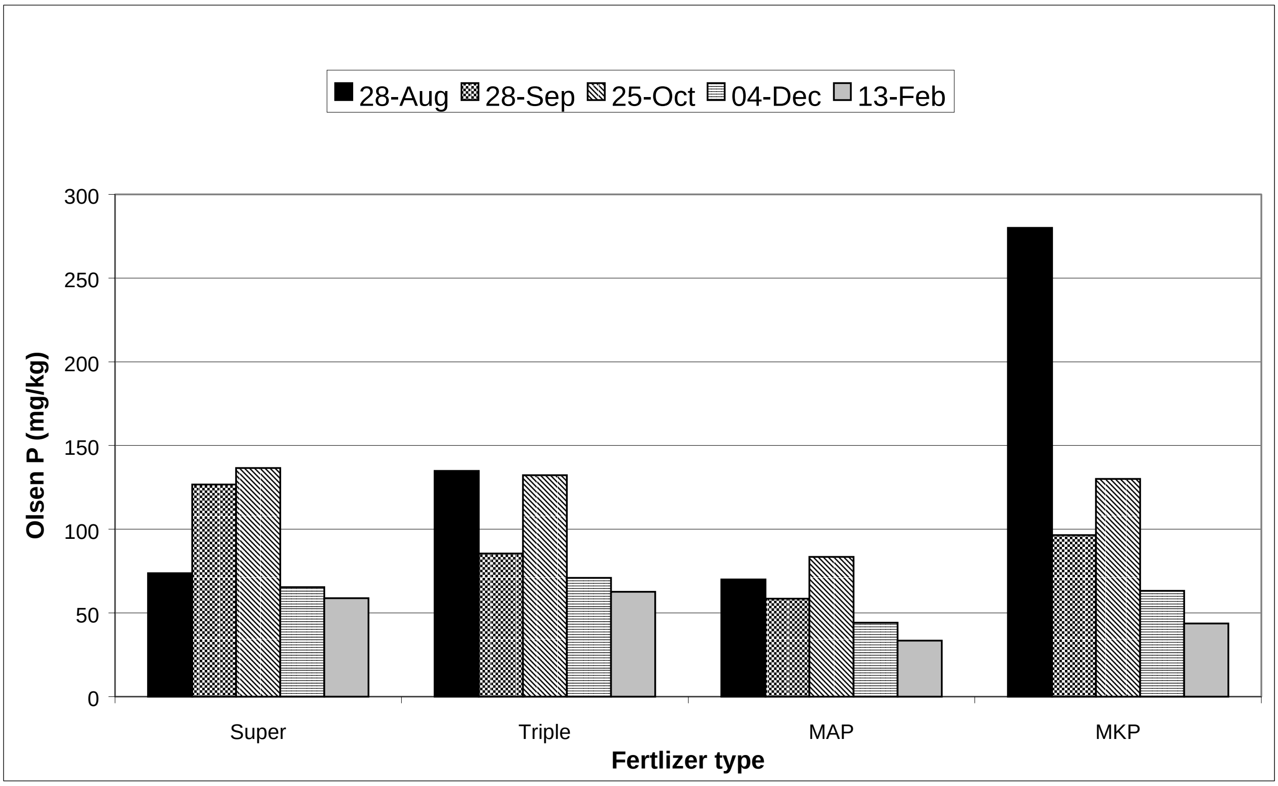

Figure 1. Changes in soil (Olsen) phosphorus following application of four forms of phosphorus fertiliser

Discussion:

Major problems exist for determining phosphorus levels in soils in relation to what is actually available for the plant, what is adsorbed, and what is fixed. Both the Olsen and Colwell methods estimate soil solution phosphorus (i.e. what is available for the plant), and a varying proportion of the adsorbed P. As the Colwell method uses a longer extraction period, it estimates a higher proportion of this adsorbed amount. The ability for the soil to store P by adsorption (as a reservoir) and re-release it into solution is known as its buffer capacity (Moody and Bolland 1999). Using a test developed by Burkitt et al. (2000) it was found that Ti Tree soils have a low to very low buffer capacity (average P_{si} index <25). Therefore, a soil with a low buffer capacity will have a much lower critical value for Colwell P than a soil with a high buffer capacity.

One way to address the issue of estimating soil solution P is by using calcium chloride to extract soluble phosphorus only (Moody et al. 1983). Limited work has been done on this to date, and may need to continue in order to assess the availability of phosphorus resulting from the addition of fertilisers.

References:

Burkitt, L.L., Moody, P. W., Gourley, C. J. P., and Hannah, M. C. (2000) A simple phosphorus sorption index for Australian soils, Australian Journal of Soil Research.

Moody, P. W., Haydon , G. F., and Dickson, T. (1983). Mineral nutrition of soybeans grown in the South Burnett region of south-eastern Queensland. 2. Prediction of grain yield response to phosphorus with soil tests. Australian Journal of Experimental Agriculture and Animal Husbandry, **23**, 38-42

Moody, P. W. and Bolland, M. D. A. (1999). Phosphorus. *In* Soil Analysis; an interpretive manual, Pererill et al. (Eds), CSIRO, 12, 187-220

PROJECT Improved Management Systems for Table Grapes

Project Officers: A. Nesbitt and S. Nagarajah

Location: Alice Springs

Objective:

To evaluate the potential for increasing the effectiveness of gibberellic acid thinning sprays applied to Thompson Seedless cultivar.

Introduction:

Gibberellic acid (GA) is widely used as a thinning spray when seedless grapevine cultivars are used for table grape production (Christodoulou et al. 1968, Sarooshi 1977, and Dokoozlian et al. 2001). The thinning spray promotes flower abortion and increases rachis elongation. The reasons for flower abortion include:

- GA acting as a pollenicide (Lyn and Jensen 1966; Weaver and Pool 1968).
- Hormonal imbalances induced by GA spray.
- Increased competition for nutrients between organs caused by a sudden burst of GA- induced elongation (Gil et al. 1994).

At Ti Tree, GA at 10 ppm is used as a thinning spray. However, questions have been raised as to the effectiveness of these sprays. Ineffectiveness is unusual, as GA is often quite effective at these concentrations when used on Sultana vines in most parts of the world (Christodoulou et al. 1968; Sarooshi 1977). It is possible that GA at 10 ppm is not effective at Ti Tree because the vines inherently contain higher than normal GA levels. Evidence of this comes from the high vigour of the vines at Ti Tree. The main factors responsible for the high vigour are high nitrogen levels in the bore water and excessive irrigation. Under these conditions, it is possible that GA at concentrations higher than 10 ppm is necessary as the thinning spray (e.g. GA at 20 and 30 ppm).

Method:

The study was carried out using only Sultana vines. The GA treatments are shown in Table 1. In all, Chemwet (0.05%) was used as a wetting agent.

Table 1. Concentrations of GA used

Treatment	GA, concentration
1	10 ppm
2	20 ppm
3	30 ppm

The treatments were replicated randomly along the vine row three times. Treatments were applied at 50% capfall (i.e. per cent of calyptras (caps) that had fallen). One replicate of all treatments received a second application at 90% capfall. Berries were then observed for shatter and enlargement. Assessments were planned for berry numbers/cm, brix, acid and pH of the berry juice. Because of poor initial results, the trial was abandoned before these assessments could be made.

Results and Discussion:

Inflorescence throughout the block was generally irregular. There were irregularities in flowering rates within the vine and between vines. For example, whilst some bunches were at 90 to 100% capfall, other bunches on the same vine were at 10 to 20 % capfall. This trend was evident throughout the entire block of Sultana.

While it is most important that GA is applied at 50% bloom to achieve the best results, irregular flowering rates meant that in most cases, GA applications would be ineffective in thinning bunches. Hence, the trial was abandoned after initial observation showed these irregularities and before berry and bunch assessments took place. It is unlikely that a similar trial will be conducted in the near future.

References:

Lynn, C.D. and Jensen, F. (1966). Thinning effects of bloom time gibberellin sprays on Thompson Seedless grapes. American Journal of Enology and Viticulture, **17,** 283-289.]

Christodoulou, A., Weaver, R. J. and Pool, R. M. (1968). Relation of gibberellin treatment to fruit set, berry development, cluster compactness in Vitis vinifera grapes*. Proceedings American Society of Horticultural Science,* **92**, 301-310.

Dokoozlian, N. K., Ebisuda, N. C. and Hashim, J. M. (2001). Gibberellic acid bloom sprays reduce fruit set and improve packable yield of “Autumn Royal” table grapes. *Journal American Pomological Society*, **55,** 52-57.

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Sarooshi, R. A. (1977). Some effects of girdling, gibberellic acid sprays, bunch thinning and trimming on the sultana. Australian Journal of Experimental Agriculture and Animal Husbandry, **17**, 700-704.

Weaver, R. J. and Pool, R. M. (1965). Bloom spraying with gibberellin loosens clusters of Thompson Seedless grapes. *California Agriculture*, **19,** 14-15.

PROJECT: Develop Irrigation Management Guidelines for Table Grapes

Project Officers: **G. Kenna, A. Nesbitt and D. Salter**

Location: Ti Tree

Objective:

Develop irrigation management guidelines for table grapes in central Australia including validating crop factors.

Introduction:

Irrigation scheduling practices on commercial table grape properties in the Ti Tree area vary considerably. The under-irrigation or over-irrigation of vines can cause a range of problems and eventually affect the economic viability of the property.

Excessive applications of water to vines can cause excess vigour, especially when nitrate is present in the irrigation water, as well as other nutritional problems. Cropping and fruit quality characteristics may also be affected including a high incidence of “chicken” berries, delayed maturity and poor handling and storage characteristics. Extra pumping will also add to production costs.

Under-irrigation can also be just as detrimental to vine growth and productivity. Poor growth, lack of berry set, failure of the crop to mature including shrivelling of berries and nutrition problems can result if vines do not receive timely irrigations with adequate amounts of water.

The use of irrigation scheduling aids varies between sophisticated, state of the art telemetry, to more basic aids such as tensiometers. Regardless of the sophistication, the main aim of efficient irrigation scheduling is to enable proper interpretation of readings and then apply the correct amount of water to a crop at the appropriate time.

The Ti Tree Water Advisory Committee (WAC), a statutory body which represents the interests of water users in the district, has a strong interest in promoting sustainable irrigation practices amongst users of the resource. The WAC has identified crop water use and irrigation scheduling as a priority.

Method:

In previous seasons the amount of water applied to vines on properties in the Ti Tree area was provided to owners and managers on a per hectare basis. It was not possible to make accurate comparisons between properties on water use in vines using this method.

In the 2001/2002 season a new system was adopted based on water application to vines on individual properties on a per vine basis. This involved the following procedures:

With the cooperation of all property owners and managers the number of vines on each property was identified.

Meter readings have been recorded on a weekly basis at all production bores on properties in the Ti Tree farms area. Currently there are 15 bores in use.

Water use for the week is recorded on a computer and e-mailed to the Arid Zone Research Institute and to Scotty Balfour at the Department of Infrastructure, Planning and Environment (DIPE). The records have to be provided to DIPE as part of the agreement for holding a water allocation licence.

Evaporation and rainfall are recorded on a daily basis at Ti Tree Research Farm. Evaporation can range between 2 mm and 16 mm depending on daily temperatures and wind.

The crop coefficient is then used to determine the amount of water actually used by the vines based on the evaporation. The amount of water used by the vine depends upon the age of the vine, the growth stage i.e. budburst, veraison, and crop load. Crop factors have been determined by ongoing research. Crop factors for table grape production in central Australia are shown in Table 1.

Table 1. Crop factors used for table grape production in the Pine Hill/Ti Tree area

Month	Crop Coefficient
January	0.4
February	0.3
March	0.2
April	0.2
May	0.1
June	0.1
July	0.1
August	0.1
September	0.2
October	0.5
November	0.55
December	0.4

Using vine spacing, row spacing and emitter output data for the particular planting, it is possible to calculate the period of time the irrigation system needs to be activated to replace the amount of water used by the vine.

The meter readings from the various properties in the area and the vine numbers on those properties were used to calculate the amount of water applied on a per vine basis for any given period of time. This was then compared with the amount of water calculated as being used by a mature vine on a litres/vine basis using evaporation data and crop factors.

Results:

Reports were presented to industry regularly throughout the season detailing water use, with graphs providing comparisons of water use on a per vine basis across properties.

The data has now been collated to reflect irrigation trends in the Ti Tree Farm area throughout the season from budburst in August to the post harvest period of January to March (Figure 1.).

The vine growth stages have been separated into three distinct periods to correlate with crop water demand: (1) budburst to veraison, (2) berry ripening and harvest, and (3) post harvest. April to July is one period when crop water use is low. Although water use on properties throughout this period is monitored, it has not been included in this report.

Table 2 illustrates the maximum amount of water applied per vine (L/vine) on an individual property and the minimum amount of water applied on another property throughout this period. The estimated amount of water required for healthy vine growth and crop development and maturation purposes is also included.

Budburst to veraison
This growth period of vines requires very low amounts of water as budburst occurs and shoot growth commences. Although shoot growth is rapid, water demand by the vine remains low. The first of two root growth flushes commences shortly after shoot growth commences. Flowering also occurs during this period. Excessive applications of water, beyond the needs of the vine at this stage, is undesirable and can result in excessive berry set and problems with “hen and chicken.” Bud fruitfulness for the next season is also determined at this stage. Adequate amounts of soil moisture for vine growth are required through this period. However, over irrigation can easily occur. Crop factors range from 0.1 to 0.5.

As can be seen in Figure 2 the application of water to vines during this period varied considerably with the majority of properties heavily over irrigating in the first six weeks after budburst. This would cause excessive vine vigour with rapid shoot elongation. The additional nitrate applied with the excess irrigations would exacerbate the problem of vigour. As bud fruitfulness for the following season is determined at this time excessive canopy growth may cause unnecessary shading of buds resulting in lower levels of bud fruitfulness.

Towards the end of this period, the maximum amount of water applied was similar to the estimated water use of the vines. However, virtually all plantings were under-irrigated in this period.

The minimum amount of water applied to vines during this stage was reasonably close to estimated water use at times in the early stages; however these vines were severely under-watered later in this growth stage.

Berry ripening and harvest

After the rapid shoot development and growth, vine growth slows. Canes continue to mature and bunch development is rapid. The berries now change colour and continue to increase in size and sugar content as the acid levels begin to fall. The accumulation of sugars in the berries is attributed mainly to the increased process of photosynthesis in leaves. For this to take place adequately, sufficient amounts of water need to be available to the vine. Crop water use throughout this period steadily increases with the maximum demand for water occurring prior to and during the harvest period.

Figure 3 details water application rates (maximum and minimum) for this critical period. Although maximum water use on a property coincided with the water demand of the vine in early November, the actual water applied for the remainder of that period was considerably below the estimated water use based upon crop factors and evaporation data. Vines on the property receiving the lowest volume of water would have been stressed during this period.

The consequences of not meeting the water requirements of vines would be delayed maturity, uneven maturity within the bunch, softening of berries and the collapse of bunches in severely stressed plantings.

Although rainfall occurred in the November and December period, most of it was not significant enough to be of any use to vines (see Table 2). Rainfall of 10 mm or less in a 24-hour period is regarded as not contributing to the vines water requirements. Much of the rainfall that occurred during this period consisted of falls of 10 mm or less. Irrigation should have continued to meet the water needs of plants.

Table 2. Rainfall and evaporation data on a weekly basis for November and December 2001

Month and Week	Rainfall (mm)	Evaporation (mm)
November 2001		
1 to 7	2.5	57.0
8 to 14	72.5	34.5
15 to 21	2.8	54.8
22 to 30	12.5	75.1
December 2001		
1 to 7	0.5	50.6
8 to 14	28.5	36.8
15 to 21	71.0	50.2
22 to 30	7.5	76.7
Total	205.8	435.7

Post-harvest

During this period, vine growth continues at a steady rate and canes continue to mature. Older leaves in the shaded areas of the vine turn yellow in colour and may fall. These leaves are not contributing to vine growth and are replaced by new growth at the ends of the canes. A second flush of root growth commences shortly after harvest.

During this growth stage the vines are storing carbohydrates and other nutrients for next season's growth. The growth of lateral shoots is greatest at this stage.

Higher levels of sodium and chloride can be found in the soil at this time of the season. The application of a number of leaching irrigations reduces these levels and ensures that salt does not accumulate in the vine.

Figure 4 indicates that irrigations during this growth stage of the vine did not meet the requirements of the vine. Generally the water requirements of the vine increased as summer temperatures were experienced through the post harvest period.

While excessive vigour is undesirable at this time, adequate water applications are required to ensure the health status of vines is optimal as pruning approaches.

Discussion:

The scheduling and application of irrigation water to meet the requirements of the vine and ensure satisfactory crop development is essential for the production of early, high quality fruit.

The water application data presented indicates that when the water needs of the vine were low in the period immediately after budburst, water applications tended to be in excess of the actual requirements of the vine.

After flowering, the water requirements of the vines increased substantially. However, most vines did not receive adequate amounts of water.

Data for the berry maturation and harvest period indicates that crop water applications did not meet the requirements of the vine for this crucial period.

This trend continued through the post harvest period when adequate amounts of water are required to promote some vine growth and maintain salt levels in the soil at acceptable levels.

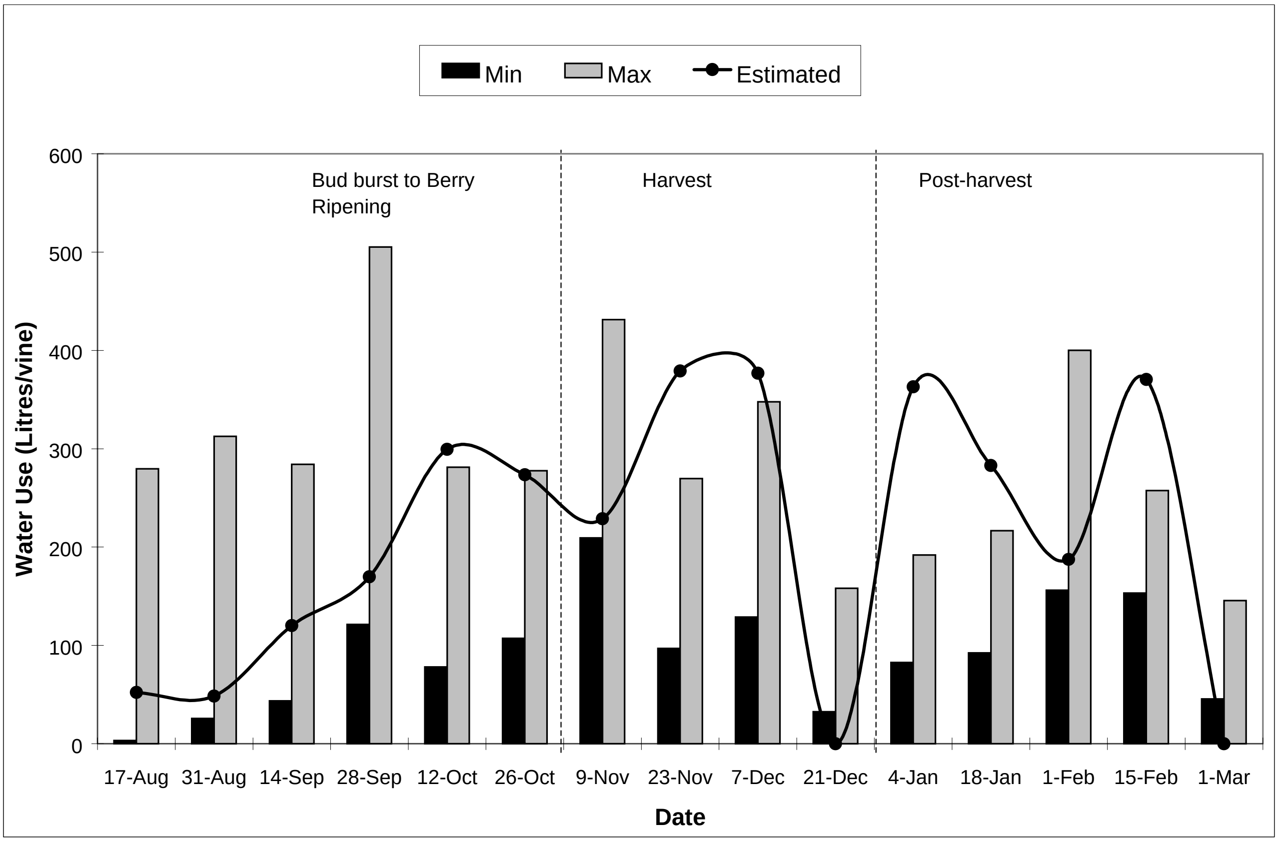


Figure 1. Range in water use and estimated vine needs for the entire season

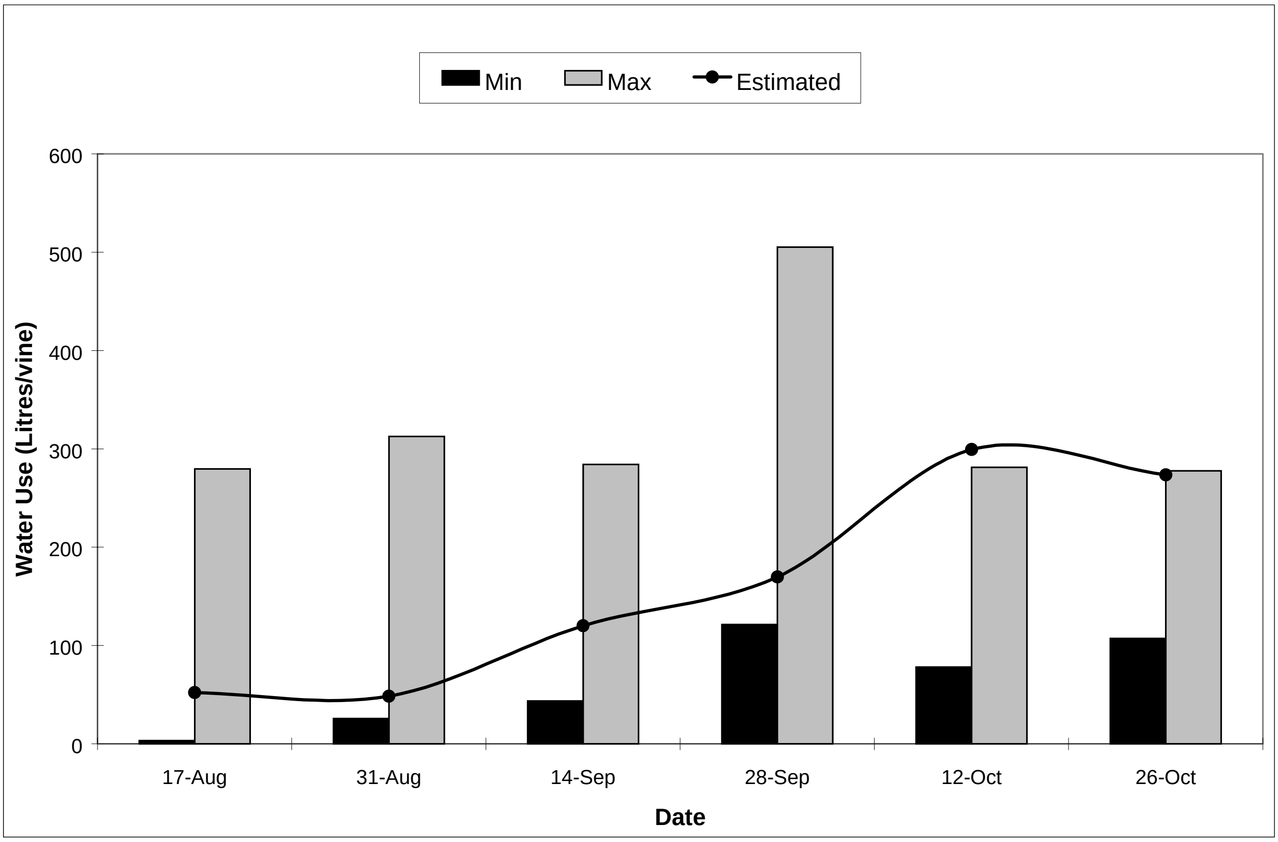


Figure 2. Range in water use and estimated vine needs for the period bud burst to veraison

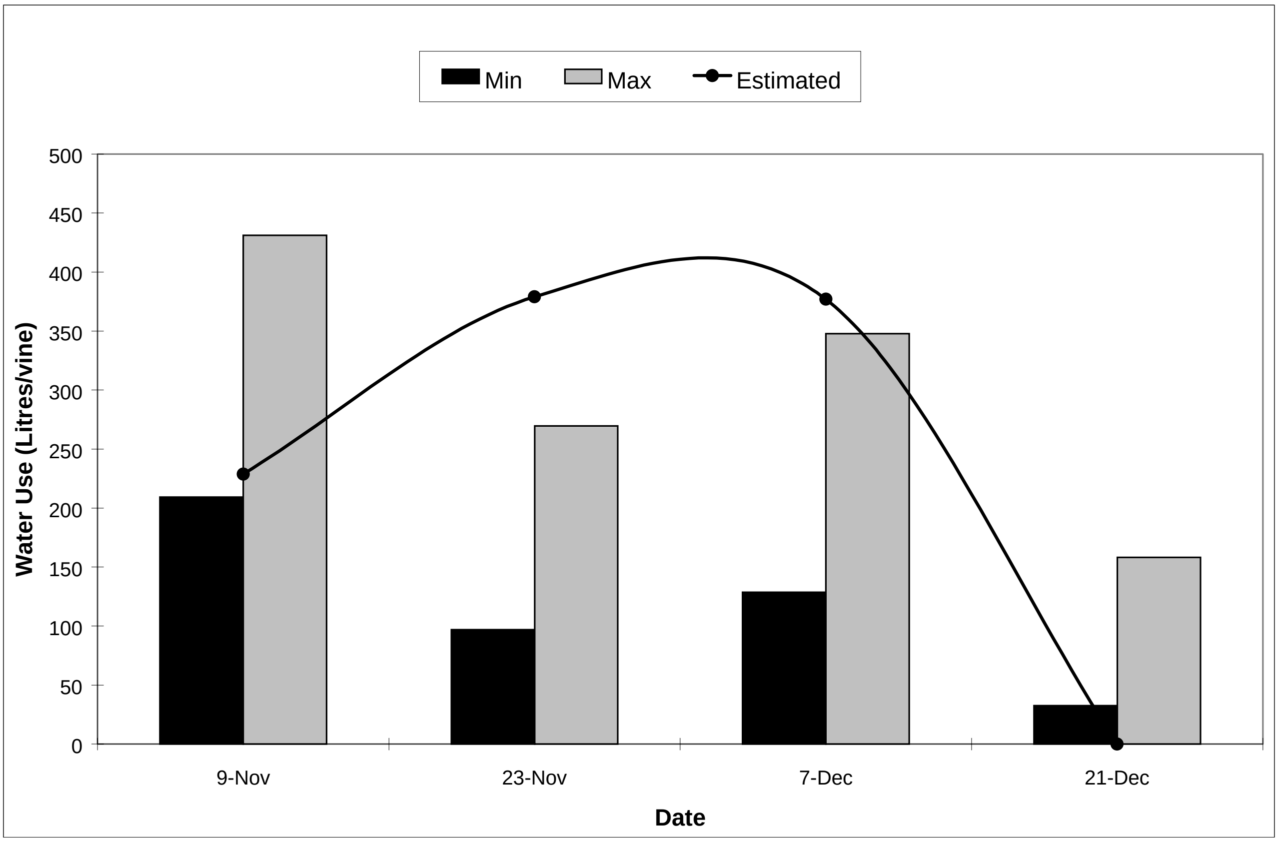


Figure 3. Range in water use and estimated vine needs for the berry ripening and harvest period

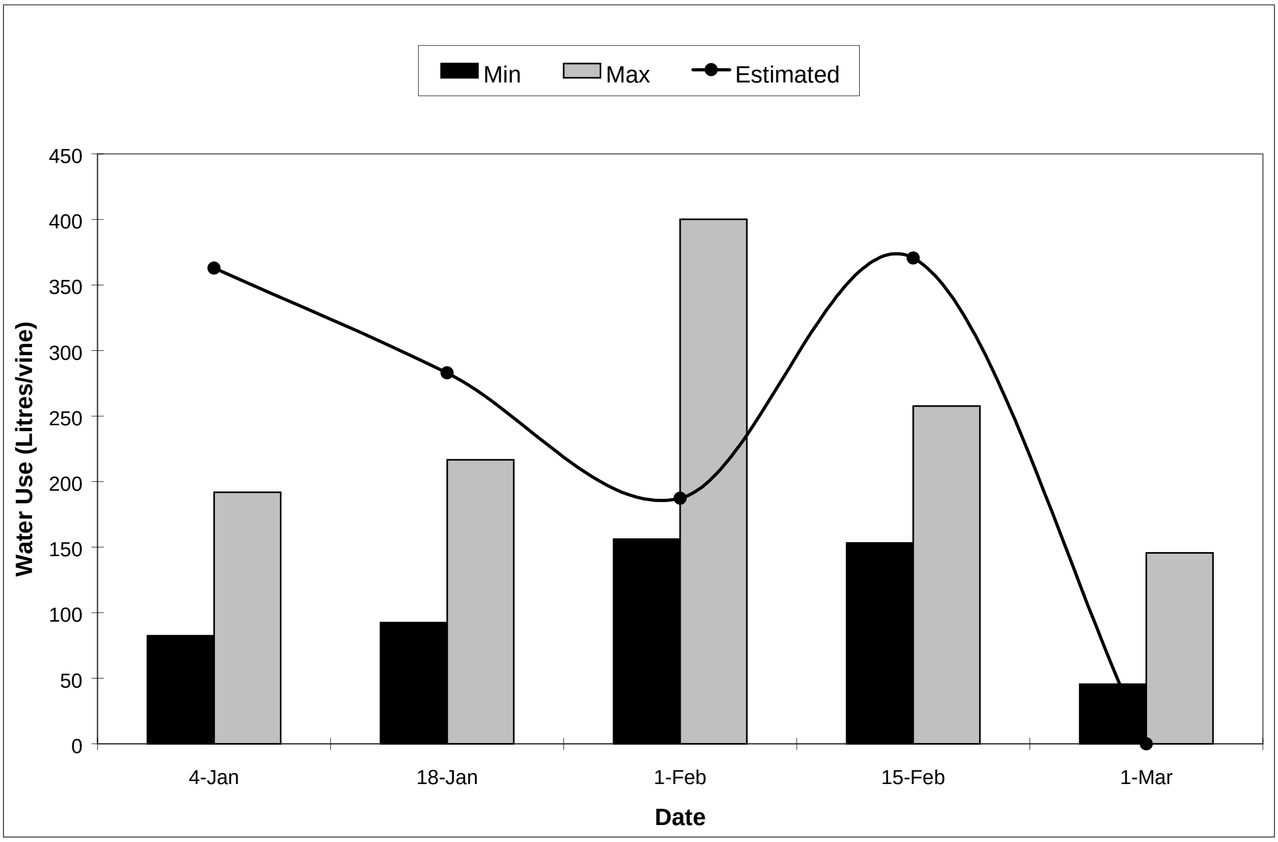


Figure 4. Range in water use and estimated vine needs for the post-harvest period

PROJECT: Improved Management Systems for Table Grapes

Project Officers: **G. Kenna, A. Nesbitt, D. Salter and D. King**

Location: Ti Tree

Objective:

Evaluate the performance of various table grape scion/rootstock combinations growing on properties in the Ti Tree area for production of high quality, early maturing fruit.

Introduction:

The table grape industry in central Australia is relatively new. The first commercial plantings of table grapes were established in the Ti Tree area in the early 1970s. However, the industry expanded at a rapid rate only over the last five years.

Initially most plantings were established using vine rootlings. Industry at that stage did not consider the use of rootstocks for nematode resistance as virgin soils in the area were identified as being free of those types known to cause economic damage to grapevines. Industry had concerns that the nitrate levels in bore water in the Ti Tree area could lead to management problems and have a detrimental effect on fruit quality due to excess vine vigour. Other positive attributes that rootstocks may have were considered of secondary importance to vigour.

The standard trellis system used by all growers in the district is the sloping T trellis. This was found to cope with vine vigour and cropping characteristics of vines grown in the area including an acceptable standard of fruit quality.

As plantings have continued to increase there have been a number of issues that have led to a dramatic change in industry attitudes to the use of rootstocks. The pest and disease-free status of vine rootlings imported into the NT in the past has been questionable. In many instances rootlings were infested with root-knot nematode (*Meloidogyne* sp.). While tests in previous years revealed no trace of root-knot nematode, this pest can now be detected in most, if not all, plantings of vines grown on their own roots or sultana roots throughout the Ti Tree area. Some vines on properties are now marginal in terms of economic viability due to infestations of root-knot nematode.

At a rootstock workshop conducted by this Department in May 2001 industry agreed that the need to consider the use of rootstocks for table grape production was overdue. Many property owners had already ordered a range of rootstocks grafted to the three main varieties grown in the area (Flame Seedless, Menindee Seedless and Sultana). The main issue identified at that meeting was which rootstocks were best suited to the varieties grown in the area in terms of the production of early maturing, high quality table grapes.

Desirable characteristics of rootstocks identified for research and evaluation included:

- Nematode tolerance: Tolerance to the range of nematodes which can cause economic damage to table grape plantings.
- Have moderate vigour characteristics when irrigated with bore water containing high levels of nitrate.
- Have acceptable cropping characteristics including yield, fruit quality and early maturity.
- Be compatible with a range of scion varieties grown in the area.
- Have some resistance to termite attack.
- Have some slat exclusion characteristics.
- Have a high plant health status.

The need to evaluate other trellis designs was also identified as a means of coping with additional vine vigour and at the same time increasing the potential for improved vine yields and fruit quality.

Method:

With the assistance of property owners and managers the various scion/rootstock combinations growing on properties in the area were identified and vines were tagged. Varieties growing on their own roots were also included in the assessment. The rootstock/scion combinations now included in the evaluation program are listed in Table 1.

Table 1. Scion/rootstock combinations under evaluation

Scion	Rootstock	Scion	Rootstock
Flame Seedless	Own roots	Sultana	Own roots
	Paulson		Schwarzman
	Freedom		Freedom
			Ramsey
Menindee Seedless	Paulson		Paulson
	Schwarzman*	Sultana M12	Paulson
	Freedom		
	Sultana H5	Crimson Seedless	Paulson
	Schwarzman*		Ramsey
	Sultana H5		
	Schwarzman	Red Globe	Ramsey*
	Harmony		Ramsey*
	Paulson		

* Denotes comparison between vines on V trellis and Sloping T trellis

Data collection from the plantings includes:

Assessment of vine vigour: Pruning weights, light penetration into canopy

Nutrition monitoring: Petiole analysis

Assessment of crop load: Bunch counts

Yield Assessment: Yield per vine

Fruit quality assessment: Berry diameter berry weight, brix and acid measurements

As noted in Table 1, a comparison between similar scion/rootstock combinations growing on V trellis and sloping T trellis will also be made.

Results:

Only one season's data has been collected from vines. Data from at least another five seasons will be required to enable any long-term trends in scion/rootstock characteristics to be identified. Additional resources will need to be allocated to this project over the next five years to collect the data required to enable the most suitable scion/rootstock combinations for table grape production in Central Australia to be identified.

PROJECT: Valuation of Dormancy Breaking Agents for Early Table Grape Production in the Northern Territory - 2001 Season

Project Officers: G. Kenna, D. Salter, A. Nesbitt and D. King

Location: Territory Grapes

Objective:

Continue to assess the effectiveness of dormancy breaking agents for the early maturation of table grapes.

Introduction:

The table grape industry in central Australia is based on the production of early maturing, high quality fruit for the domestic market. Table grapes grown in the Ti Tree/Pine Hill area, 200 km north of Alice Springs, begin to mature in early November and the bulk of the harvest is completed by Christmas.

The amount of winter chill received by grapevines in this area varies considerably from year to year. Often budburst is slow or erratic due to a number of factors including seasonal temperatures and rainfall experienced throughout the dormancy period. This has implications for the management of the crop and can also influence the timing of harvest.

The application of the dormancy breaking agent Dormex (hydrogen cyanimide) to vines to promote an early and more even budburst has become an essential management practice in the vine growing areas of central Australia. This chemical is usually applied to grapevines at the maximum recommended rate of 5% v/v (2.5% active ingredient), with the addition of a non-ionic wetter at the rate of 50 mL/100 L of spray solution.

Past research has indicated that the method of application of the spray mix - the volume applied and how well the spray is targeted - determines the effectiveness of the spray. At least 400 mL of spray needs to be applied per vine (500 L/ha). Industry has identified an ongoing need for further research to improve the effectiveness of Dormex because of its cost and varied response in plantings from year to year.

Dormex Research Project – 1999
Research work in 1999 involved assessing the effectiveness of Dormex when combined with various surfactants and applied at various rates. This was compared with Dormex applied at the standard recommended rate including non-ionic wetter.

Dormex Research Project – 2000
Research was conducted in 2000 to assess the effectiveness of a number of treatments which had been used the previous year as well as a number of new Dormex/surfactant spray mix rates.

Dormex Research Project – 2001
Further evaluation of the effectiveness of one of the more promising Dormex/surfactant combinations compared with the standard recommended Dormex/surfactant combination was conducted in season 2001. A relatively new product, which has dormancy breaking properties, “Waiken”, was also evaluated against the two Dormex treatments. Waiken is Australian developed and manufactured. The evaluation of this product was conducted in cooperation with the management of Territory Grapes and the manufacturers of the product.

Treatments and cultivars consisted of the following:

Flame Seedless:	Dormex 5% v/v and Chemwet 1000, 0.06% v/v Dormex 2% v/v and Chemwet 1000, 3.00% v/v Waiken 6% v/v and Chemwet 1000, 0.03% v/v Waiken 6% v/v
Sultana:	Dormex 5% v/v and Chemwet 1000, 0.06% v/v Dormex 2% v/v and Chemwet 1000, 3.00%v/v Waiken 6% v/v and Chemwet 1000, 0.03% v/v Waiken 6% v/v

Method:

The trials were conducted in two commercial table grape plantings at the Territory Table Grape Farm property (190 km north of Alice Springs). The plantings comprised *Vitis vinifera* cultivars Flame Seedless and Sultana on own roots. Flame Seedless vines were spur pruned and the Sultana vines were cane pruned.

Treatments were applied to plantings on 1, 3 and 4 of July 2001. The treatments were applied using accepted commercial Dormex application methods using a boom-spray arm mounted on a 3,000 litre trailed spray unit.

Ten two bud spurs were marked on 10 vines in each treatment in the Flame Seedless. Twenty buds were marked on 10 vines in each treatment in the Sultana vine rows.

The marked buds on the spurs and canes of vines in the various treatments were assessed twice weekly commencing the first week of August. The effectiveness of the treatments was determined by comparing the number of days after treatments had been applied for the marked buds to reach budburst. An acceptable level of budburst was considered to have been reached when 80% of the buds marked on vines reached budburst.

Results:

Results were very variable in terms of the budburst rate between some treatments and the total number of buds that actually burst across all treatments in a specific variety.

Flame Seedless
The Dormex 5% Chemwet 0.06% treatment achieved a budburst rate of 80% budburst, approximately 39 days after application.

The Dormex 2% Chemwet 3% treatment achieved a satisfactory budburst rate with approximately 80% of buds having burst approximately 48 days after application.

Waiken 6% Chemwet 0.03% vines achieved 80% budburst 58 days after application.

The Waiken 6% treatment vines had almost reached 80% budburst 64 days after application (see Figure1).

Sultana
Budburst in the sultana plots was very poor with all vines achieving a budburst of not more than 50%. A similar pattern was observed in the rest of this block and a similar pattern was evident in many plantings on other properties throughout the area.

Dormex 5% Chemwet 0.06% achieved approximately 32% budburst 74 days after the spray application.

Dormex 2% Chemwet 3% achieved the highest rate of budburst and a total budburst of 50% approximately 74 days after spray application.

Waiken 6% Chemwet 0.03% achieved 50% budburst 74 days after spray application; however the budburst rate was much slower. Only 7% of buds on these vines had burst 58 days after spray application. Budburst was quite rapid in the next 16 days.

Waiken 6% had a similar budburst pattern to the Waiken/Chemwet combination; however it had not achieved 50% budburst when the assessment was completed (see Figure 2).

Discussion:

Budburst this past season was perhaps one of the worst, if not the worst for many years. While budburst in some plantings on some blocks was satisfactory the general trend on many blocks was a delayed budburst with many of the buds remaining dormant. In many blocks budburst occurred at the ends of the canes with delayed, or no budburst in the crowns of the vines and in the bud positions number 4 to 8. The severity of this problem in some plantings becomes very obvious as pruners look for replacement canes for this season's fruiting wood.

Both Dormex treatments on Flame Seedless performed satisfactorily, with the standard Dormex rate the best performer.

All treatments on Sultana were disappointing with the Dormex 5% Chemwet 0.06% combination performing very poorly compared with previous seasons when that spray mix was one of the better performers. Dormex 2% Chemwet 3% was the best of the treatments; however its performance was not at an acceptable level this season.

Waiken with and without a surfactant resulted in vines having a very slow initial budburst that improved late in the period of budburst. There were no untreated vines to compare with these treatments to assess whether they were ahead of vines that were not sprayed with any dormancy-breaking agent.

Further Work:

It is difficult to provide an explanation for the poor budburst. There are however a number of issues which can be addressed with further work next season in an effort to improve budburst rates.

There have been discussions in the past about the effect humidity levels in the air have on the rate and evenness of budburst. Budburst rates achieved on at least one property in this season were well above the average. Dormex was applied on this property late in July after rain. This may have enhanced the effect of Dormex.

Weather data from Territory Grapes indicates that humidity levels rise from 20%RH at 1800 hours and peak at 85%RH at 0600 hours the next morning. Will Dormex be more effective if applied in the early hours of the morning?

The acceptable volume of Dormex/surfactant applied per vine has been about 400 mL/vine. To increase the effectiveness of the spray, higher rates per vine may need to be applied. Volumes up to 800mL/vine may be necessary.

How easily can the dormancy-breaking agent penetrate the bud scales to trigger budburst? During cold, dry seasons much of the dormancy agent may evaporate off the surface of the bud and not penetrate the scales. Softening of the bud scales to improve the effect of the dormancy agent by applying water or a wetting agent prior to the Dormex spray may improve the effect of the dormancy spray.

The wrapping of canes on three wires rather than two may assist a more even spray application, provide more exposure to the buds for the spray and result in a more even budburst.

Data loggers to record air temperature, humidity and soil temperature need to be placed in a number of vine plantings to record data prior to and after the application of dormancy-breaking sprays.

The agent Waiken may require further investigation to determine whether it is an acceptable alternative to Dormex.

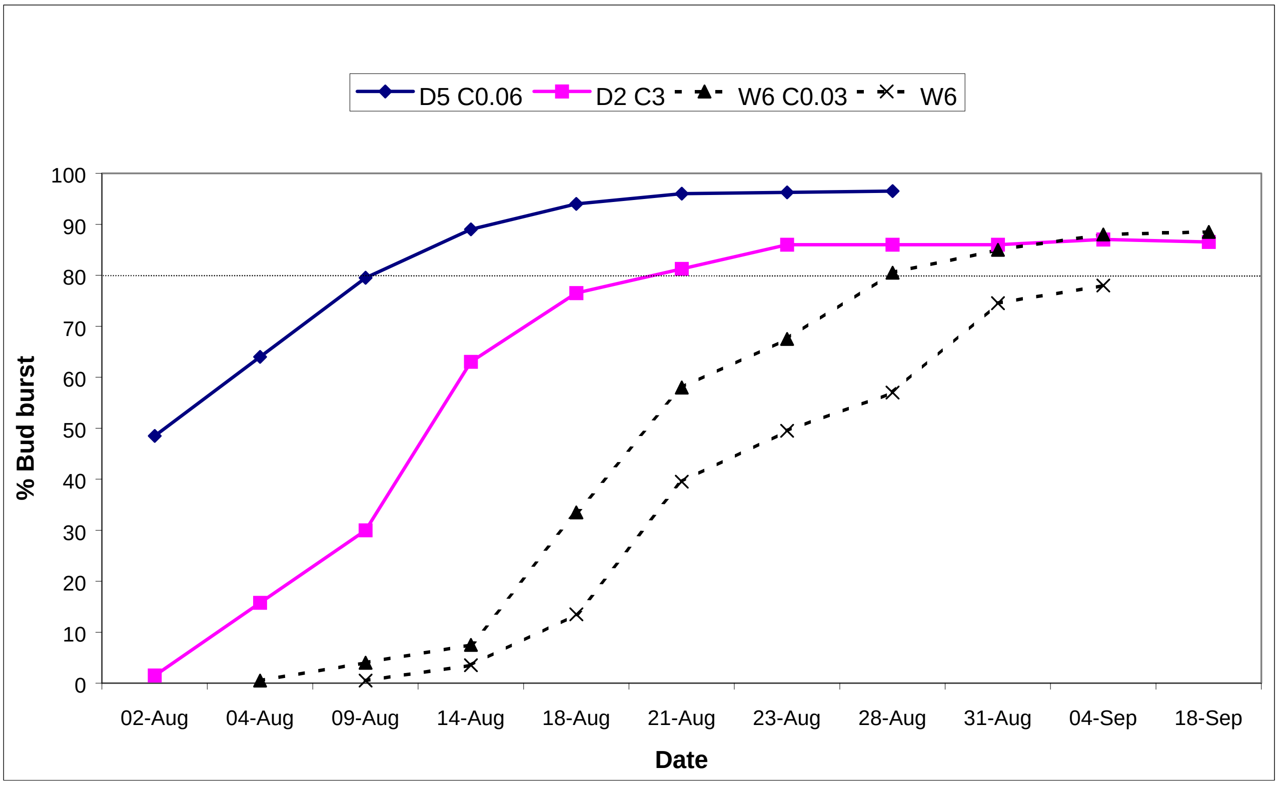


Figure 1. Percentage budburst for various dormancy breaking treatments in cultivar Flame Seedless

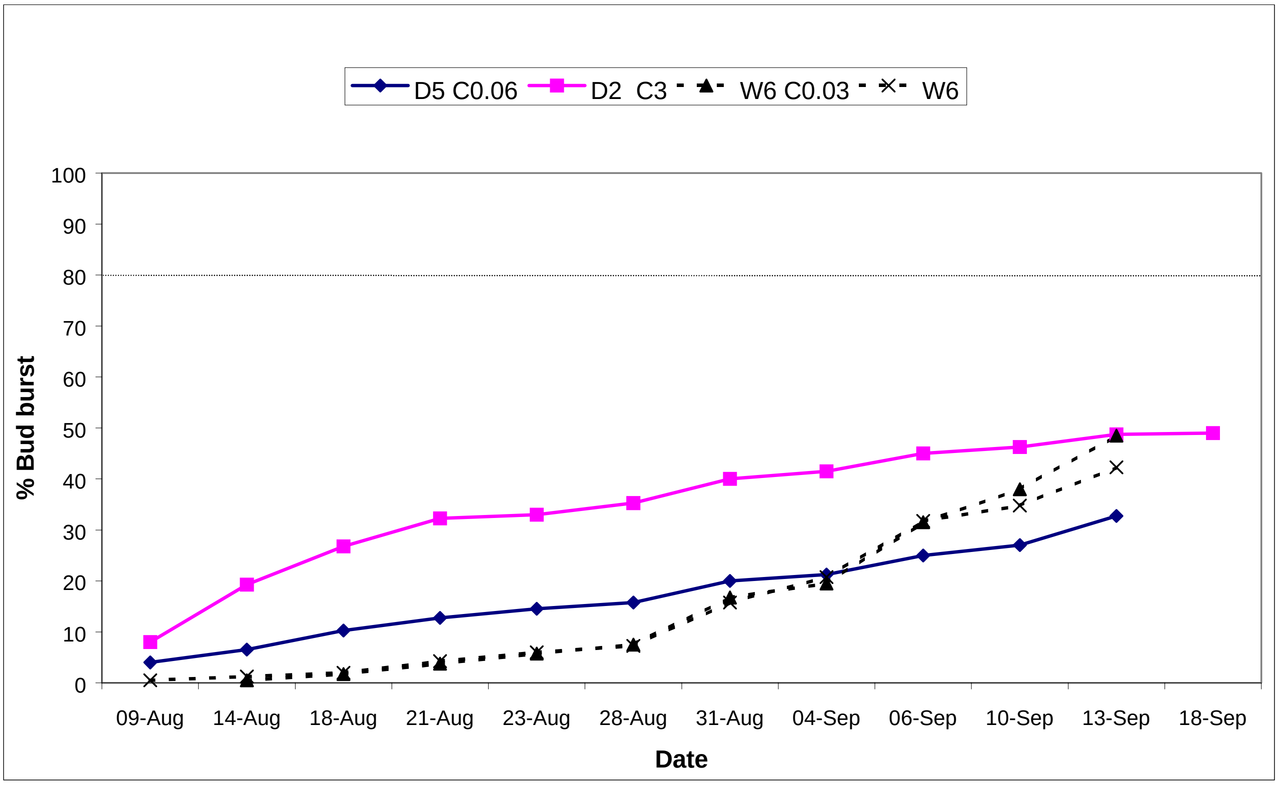


Figure 2. Percentage budburst for various dormancy-breaking treatments in cultivar Sultana

SUBPROGRAM: Bananas

PROJECT: Banana Tropical Race 4 Panama Disease Management

Project Officers: **M. Darcey, G. Walduck, C. Kelly and A. Daly (Plant Pathology)**

Location: CPHRF

Objective:

To find and develop a commercially acceptable banana variety resistant or tolerant to Panama Tropical race4 for the NT banana industry and to simultaneously develop field management methods to reduce the spread of the disease.

Specifically:

1. To commission and operate a world class Quarantine Facility capable of undertaking secure research on Fusarium oxysporum. cubense - Tropical Race 4 [Foc4].

2. To locate and screen banana varieties for resistance or tolerance to Foc4 within the secure quarantine facility while ensuring no spread of Foc4 from the facility.

3. To test the commercial acceptability of any variety found resistant or tolerant to Foc4.

4. To develop and commercialise any resistant or tolerant variety found to be commercially acceptable.

5. To develop field management techniques aimed at reducing the spread of the disease.

6. To attempt to develop field techniques aimed at disinfesting currently infested areas.

Progress:

1. Construction of the Coastal Plains Banana Quarantine Station [CPBQS] was completed and was officially opened on 2 July 2001.

2. During June and July the Coastal Plains Banana Quarantine Area [CPBQA] was planted with sacrificial plants and 14 test varieties introduced from overseas and Queensland Department of Primary Industries researchers.

3. Another six potentially resistant lines have just been released from post entry Quarantine in Queensland and are being imported into the NT to undergo testing at CPBQA.

4. Quarantine Protocols for CPBQS AND CPBQA were implemented on 22 August. CPBQS and CPBQA and the associated protocols were officially proclaimed on 29 October 2002 after extensive testing.

5. The CPBQA sacrificial plants were inoculated on 1 November 2001. These plants developed infection and successfully and evenly infected the site and subsequently the susceptible test plants planted between them.

6. The operating protocols were externally audited on 7 November 2001 and have been internally audited twice. The system has passed all audits to date.

7. On 18 December 2001, the first external symptoms of FOCTR4 were observed on the Pissang berungan [Lakatan] sacrificial plants. The onset of symptoms was much more rapid than we had been expecting and within six weeks most of the sacrificial plants were showing symptoms. The results are summarised in Figures 1 and 2, and show clearly:

   - how even and thorough the inoculation process was with all plants showing symptoms within 12 weeks and 95%+ dying within 27 weeks;
   - how quickly the symptoms develop with most plants progressing from first symptom to death of the top in five to six weeks.

8. The causal organism was confirmed as FOCTR4 [VCG 2013012/16] by isolating from plants showing Panama Disease and conducting VCG and PCR testing at Plant Pathology Laboratory BARC.

9. Preliminary data from test plants indicated:

   - Lakatan is much more susceptible than other varieties tested.

   - Tissue cultured Cavendish [Williams] plants succumb to the disease much more quickly than plants planted as bits or suckers. This confirms earlier observations on Panama Temperate Race 4 in SE Queensland.

   - Cavendish [Williams] is susceptible but results are not yet complete enough to confirm any resistant plants at this stage.

10. Agronomic data on test plants.

    This data is preliminary and somewhat fragmented as the assessment plots were blown down in storms in November and December 2001. The data below indicates that at least some of the test varieties are acceptable in terms of taste.

11. Studies on rates of spread.

    - A number of studies are being commenced at both CPBQA and on commercial sites but no data is available at this time.

12. Trial to test a range of biological agents potentially capable of slowing or suppressing FOCTR4 infection on Cavendish [Williams] has just been commenced at CPBQA but no data has been generated.

13. Project to assess host status of certain common weeds growing in the infected area at CPBQA. This is being conducted by an honour student from the NT University and will generate data next year.

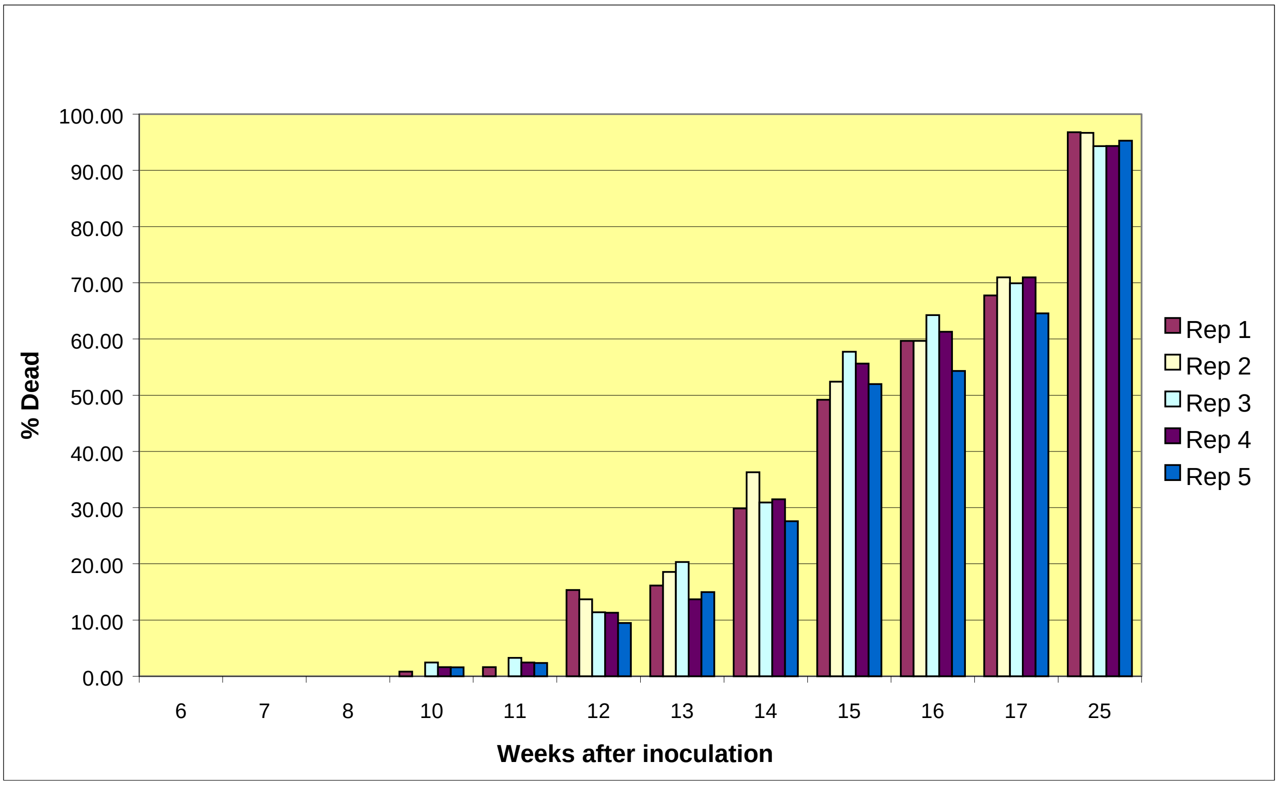


Figure 1. Rate of lakatan deaths in each rep

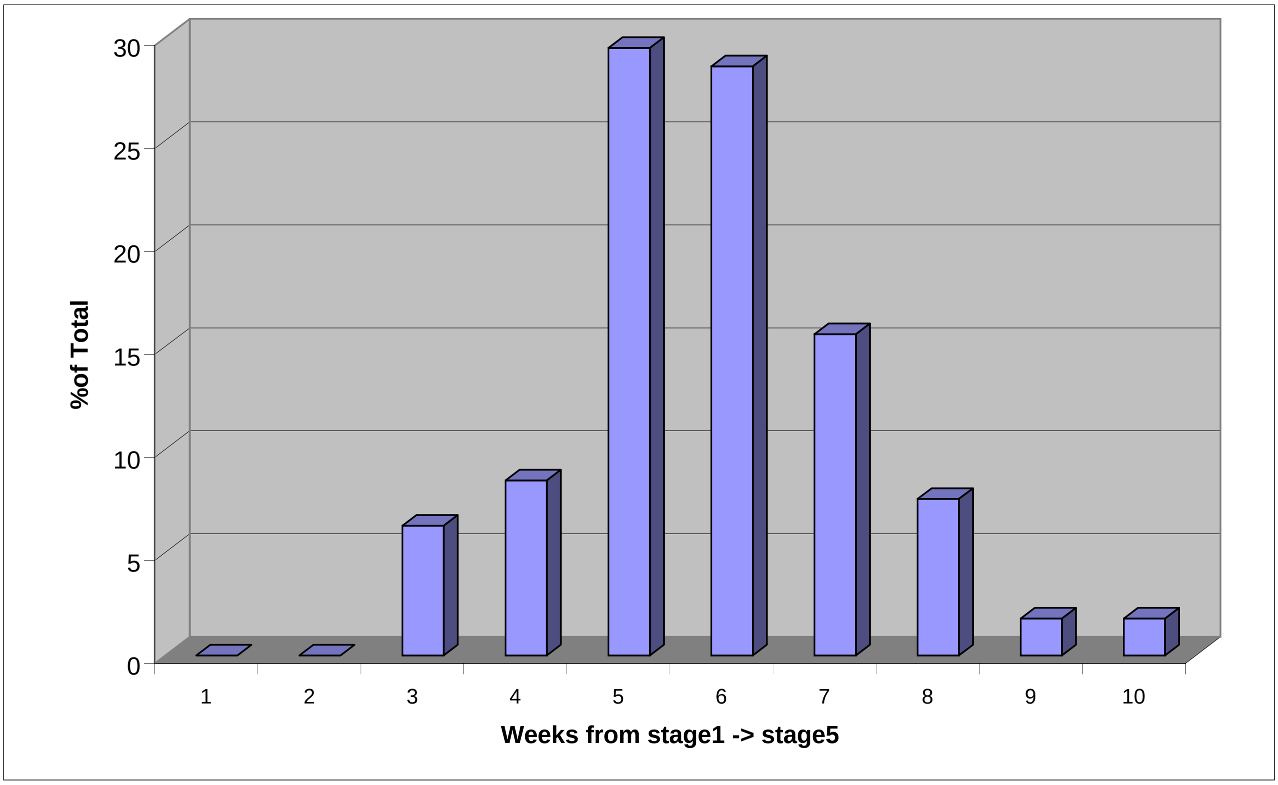


Figure 2. Time for inoculated Lakatan plants to progress from first symptom (stage1) to death of top (stage 5).

Table 1. Agronomic and bunch characteristics of some test varieties

	Var.					
	1	2	3	4	5	6
Plant crop, inoculated site						
Planting to bunch emergence (wk)	41.7	51.3	44.4	46.3	48.5	50.3
Ratoon crop, clean site						
Bunch emergence to bunch harvest (wk)	11.67	13	13		14.5	18
Height at harvest (cm)	2.3	2.9	3.07		3.25	2.95
Girth 1 metre from base of pseudo-stem @ harvest (cm)	88	63	92		80.5	94
	Var.					
	1	2	3	4	5	6
Average bunch weight (kg)	22.16	24	28		18.76	41.5
Average fruit weight per bunch (kg) *	19.1	21.5	24.2		15.48	34.51
Average stork weight including false hand if any (kg)	3.06	2.5	3.8		3.28	6.85
Average number of Hands per bunch	8.67	7	10		12	16.5
Average number of fingers per bunch	137	133	157.33		207.75	336
Average number of fingers on third hand	16	20	16.67		17.5	22.5
Average finger length on third hand (mm)	188.33	205	196.67		129.5	175
Average hand weight on third hand (kg)	2.33	3.2	2.73		1.13	2.58
Taste (% acceptable)	100	100	60			0
Ripe fruit color						
Bunch Photo	no	yes	yes	no	yes	yes

* Excludes false hand which is included in stalk weight

SUBPROGRAM: Tropical Exotics

PROJECT: Miscellaneous Fruit Research

Project Officer: G. McMahon

Objectives:

Research, identify and evaluate suitable fruit crops for Top-End production.

Multiply and release known Pitaya varieties and low land Longan varieties to industry.

Identify suitable multiplication techniques, and develop best management practices for Top End conditions.

Longan

The Vietnamese low land longan continues to be assessed for growth, phenology and suitability as a fruit crop for local conditions. Some of the second planting of *mata kuching* and others that had failed to establish have died and there have been some losses to termites.

The irrigation system was changed from sprinklers to 8 L/h drippers in order to reduce the water-logging of the site that caused stress in trees.

Several trees flowered in September and fruit was harvested in December. Fruit size and weight are shown in Table 1.

Table 1. Sample from the longan harvest

Fruit size	No. of fruit	Average weight (g)	Total weight (g)
Large	28	16.32	475.10
Medium	20	13.25	265.04
Small	17	9.89	168.25

Fruit was of average size with thin translucent flesh and a large seed. Further harvest data will be collected this year, which will give a better indication of potential yield.

Pitaya

The trial at CPHRF is continuing and plants are becoming quite large and require pruning. Flowering, fruit development and harvest data was collected this year. This data has yet to be analysed but some interesting trends can be seen:

- One variety produced large numbers of flowers and only one fruit.
- Another variety produced fruit from every flower.
- Flowering occurred in six-week cycles, with some plants producing several crops.
- White flesh produced fruit earlier than red or yellow.
- Time period from bud emergence to harvest is consistently six weeks

A brief summary of the yield data collected for two varieties is shown in Table 2.

Table 2. Yield data for the 2002 season

Cultivar	No. of plants	No. of fruit	Total weight (kg)	Average weight (g)	Yield/plant (kg)
Ex Vietnam	4	47	18.100	385.11	4.525
Bin Than	4	34	9.597	282.28	2.399

Katherine Exotic Arboretum
The on going evaluation of several exotic fruit crops for the Katherine region has been written and will be published as a Technical Bulletin.

Briefly, the project was to shortlist and release potential cultivars of various tropical fruit suitable for production in the Katherine region. Twelve cultivars of avocados were evaluated and five showed some potential. Each of these cultivars suffered some problems, which can be rectified with appropriate management practices. A summary of the yield data for the 2002 season is given in Table 3.

Table 3. Avocado harvest data

Cultivar	No. of trees	No. of fruit	Weight (kg)	Average weight (g)	Fruit fall	Yield/tree (kg)
Victoria	2	11	9.100	827	22	13.64
Tower 2	1	16	3.500	218	29	9.81
Peterson	2	4	1.950	487	77	19.72
Kimberly	2	14	3.200	228	142	17.78
Zutano	1	59	8.100	137	91	20.55

Fruit numbers were very low due to the heavy fruit drop that occurred before the fruit was harvested. Zutano, which was used as the rootstock in the trial, produced a good harvest, although fruit quality was poor. Victoria produced large fruit, but with a large seed which reduced the amount of flesh. Peterson produced a smaller fruit but with a smaller seed which resulted in a larger amount of flesh.

Information on the remaining exotic crops that were evaluated is being prepared for publication.

PROJECT: Northern Australia Cocoa Development (RIRDC Project DAQ-256A)

Project Officers: C. Wicks, J. Orchard, N. Leibel and G. Dunker

Location: CPHRF

Objectives:

To generate an in-depth knowledge of cocoa production in northern Australia.

Using that knowledge, to refine an economic model for cocoa production with the aim of determining the economic viability of cocoa production in northern Australia.

In late 1997, Cadbury Schweppes Australia approached the then DPIF, Agriculture WA and Queensland DPI with a proposal to commence a collaborative feasibility study to develop a cocoa industry in north Australia. Cadbury Schweppes is concerned that the increasing demand from Eastern Europe and China, combined with the continuing problems with supply from traditional cocoa growing areas may lead to a shortfall in production. Currently cocoa prices are rising as forecasted.

At present Australia imports approximately 40,000 tonnes of cocoa (dry bean equivalent) for its chocolate, beverage and confectionery requirements. To replace half of this requirement, at an average yield of 4 tonnes/ha of dry beans, would require 5000 ha of producing trees. At current world prices, the value of this production would be $50m per annum.

After various study tours and an economic analysis by an independent consultant, a number of meetings were held. Those attending included representatives from NT DPIF, Cadbury Schweppes, the Rural Industries Research and Development Corporation (RIRDC), QLD Department of Primary Industries and the WA Department of Agriculture. These organisations agreed to form the "North Australia Cocoa Development Alliance", which will coordinate all activities, including future commercial development, subject to feasibility of the crop. It was agreed that the NT DPIF would be directly involved in cocoa yield evaluation and clonal introduction projects.

Both these projects are progressing well. The problems with sourcing the first-choice seed for the Hybrid Evaluation Trial from Malaysia that were discussed last year, made it necessary to use material from PNG. The planted crosses (in order) are KA82 x KEE5, KA82 x KEE12, KA2-106 x KEE12 and KA2-106 x KEE23. A fifth cross, KA82 x KEE43 was also purchased but is not being used in the hybrid trial as it is susceptible to *Phytophthora* diseases and vascular streak dieback. These lines have been planted and assessment has commenced. Table 1 shows that there are some differences between the lines as well as between the single and double planting systems.

Table1. Lines planted in the trial

	June 2002		Planting density			
Hybrid		**Single**			**Double**	
	Jorquett %	**Jorquett height (cm)**	**Total height (cm)**	**Jorquett %**	**Jorquett height (cm)**	**Total height (cm)**
H1	100	107	208	100	110	217
H2	100	113	219	100	116	232
H4	100	115	227	100	114	231
H5	100	110	233	100	110	231

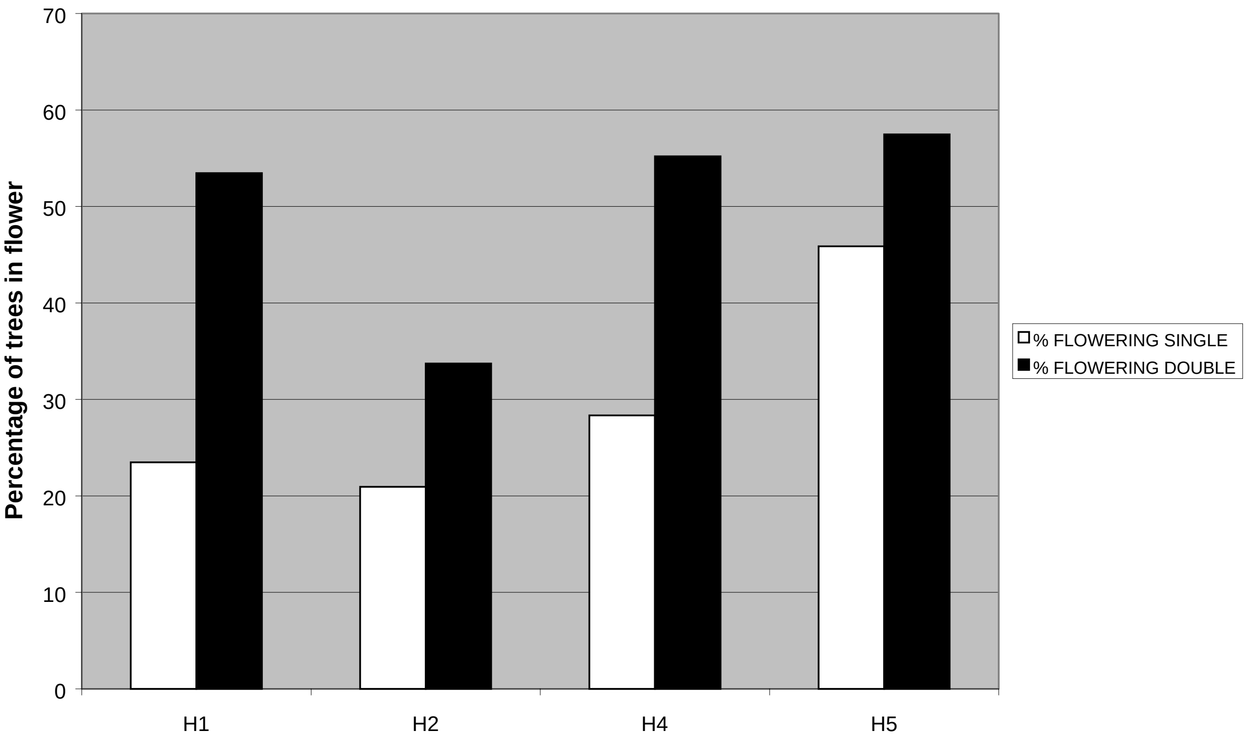


Figure 1. Rate of flowering in second year

The clonal material has been collected from the Cocoa Germplasm Collection at Reading University, UK. The lines requested from the UK were NA33, PA300, Amaz1515, ICS1, IMC67, P4A, P4B, EET399, SCA6, SCA11, and SCA19. These lines are all now in the NT and were planted in a small trial under shade during October 2001. The trial consists of four replicates of each of the 11 varieties and will be used to assess growth rates and yield as well as to supply material for future multiplication.

An irrigation trial was also conducted to determine the best irrigation strategy for maximising cocoa production in the NT. However due to poor seedling material and harsh environmental conditions at the time of planting, the project is under review.

Melbourne based company Timber Corp has joined with NACDA as a financial contributor and in mid 2002 Agriculture WA stopped work with the project. A report on the outcomes is available.

As part of Cadbury Schweppes commitment to cocoa research in Australia, they are sponsoring a Ph.D project in the NT by Mr Nathan Leibel, under the supervision of the University of Technology, Sydney and the Northern Territory University. He is working mainly on the physiological responses of cocoa plants to the long light regimes in the NT. The work will develop ways to use shade for cocoa production in north Australia.

This project is planned to finish in 2003.

PROJECT: Improving Durian Productivity

Project Officers: **C. Wicks, G. McMahon, C. Kelly and G. Dunker**

Location: BARC, CPHRF and Mrs Siah's Durian Block at Lambells Lagoon

Objective:

In conjunction with other workers in Australia and overseas develop an integrated disease management system for controlling Phytophthora related diseases of durian.

The main objective can be expanded to the following:

- ***Identify and multiply the three most suitable varieties for the NT.***
- ***Introduce new cultivars from Malaysia, Indonesia and Vietnam, and assess for future potential.***
- ***Improve durian orchard establishment and sustainability, and the consistency of quality fruit supplies to expanding markets.***

Mulch and Green Manure Trial in the Field
The aim of this trial is to identify in the field a best practice for reducing the incidence of Phytophthora disease in durian, by using mulches and/or (ground cover) live manure. There are three mulching treatments (none, hay and hay plus chicken manure) and three live manure treatments (none, Wynn Cassia and sabi grass) which results in nine treatments in total. Each treatment is replicated four times and the entire trial is duplicated in a second block. Measurements are taken for temperatures, soil water status, tree phenology and size (including surface root assessments) plus qualitative assessments of soil biota status.

Up to now no Phytophthora has been detected. There have been some tree deaths but these can be attributed to longicorn attack, poor water management and competition from the Wynn Cassia. It has also been noted that without shading, the young trees become sickly, which may predispose them to attack by Phytophthora in the future.

The Wynn Cassia is growing so well that it has previously competed with the young trees, again possibly predisposing them to attack by Phytophthora. This competition has been reflected in the collection of data over the past two years, where tree heights prior to removal and control of this cover from the basal area of the trees was greatly restricted. Since control of this cover has been maintained a steady growth of these trees has continued.

This trial will need to continue for many years before any concrete conclusions can be made. However, it is already becoming clear that early competition from green mulching is detrimental and mulching with hay aids root growth.

Mulch, fertiliser type and fertiliser and irrigation rate trial in pots
The aim of this trial is to quantitatively identify (with trees in large pots) various management factors that may influence the incidence of Phytophthora disease in the field. Various types of organic manure of different age are being added to pots to test the hypothesis that fresh, young manure may burn the roots or introduce pathogens to the soil. Various levels of chemical fertiliser are being added to pots to test the theory that high levels of fertiliser either burn or weaken roots which then increases the incidence of Phytophthora disease. Various levels of irrigation through different application strategies are being used to test the theory that extreme cycles or levels of soil water status increase the incidence of Phytophthora disease.

There are no results to report. Efforts to inoculate the pots with Phytophthora have been unsuccessful. Alterations to the methodology have been identified and will be trialled. The other problem with the trial is the crowding which is encouraging leaf disease and causes a large degree of competition for light. There has also been a large amount of longicorn damage, which has killed trees stressed from irrigation and fertiliser treatments.

Screening, marcotting and grafting trials
The aim of this trial is to identify possible resistant varieties of durian and to test their compatibility as rootstocks with popular commercial scions. This is being done through two processes.

The first process involves testing as many durian varieties as possible (and other Durio species) with a number of *P. palmivora* isolates, from orchards in the Darwin rural area. The most resistant varieties or trees are then being vegetatively propagated to allow rootstock compatibility testing. Alongside that process is a rootstock trial using current commercial material. This trial will allow the identification of rootstock-scion interactions.

While a number of possibly resistant varieties/trees have been identified, more testing has to be done. The testing to date has been unsuccessful. The leaf bioassays being conducted have shown very little difference in either varietal resistance or isolate pathogenicity. This is due to poor cultures that, while producing sporangia, do not appear to effectively infect the plant tissue.

There has also been little success at vegetatively propagating the varieties/trees selected. Most success has come from work in North Queensland. The climate there appears to be better suited to marcotting though the number of live marcotts in the green house is less than 10% of all the marcotts attempted. Attempts to marcott trees in the Darwin rural area have obtained some success with undifferentiated (Calais) material forming at the base of marcotts; however root initiation has so far been unsuccessful with the majority of material unable to survive the extended dry period of the Top End dry season. This low level of success has also been found in the major durian growing regions in SE Asia where grafting is the typical method of plant multiplication.

Antagonists of Phytophthora
The aim of this trial is to identify and field-test fungi and bacteria that may inhibit (antagonise) Phytophthora. A large number of laboratory tests resulted in the identification of one fungus that inhibits the growth of Phytophthora on petrie dishes. This fungus is yet to be tested in the field.

This research has already identified a useful management practice for growing durian. The large majority of growers do not use living mulch. The benefits are obvious to growers, even with the increased management of living mulch particularly in the early stages of seedling establishment.

The results of this project will provide growers with some clear direction on the management practices of durian orchards to control Phytophthora related disease. This is a high priority outcome identified by the Australian Durian Growers Group in the business plan.

PROJECT: Improving Rambutan Productivity

Project Officers: C. Wicks, G. McMahon and G. Dunker

Location: Various commercial rambutan orchards and CPHRF

Objectives:

To develop rootstock/scion combinations and pruning strategies that control flowering and tree size.

To improve industry productivity by benchmarking nutrition standards.

To improve grower knowledge and use of irrigation monitoring.

The main focus of this project is on the benchmarking of nutrition standards and the uptake of irrigation monitoring systems. A system to improve/control flowering has been developed and was published in 2000. The development of pruning strategies to control tree size is being studied in Queensland. There is an opportunity to conduct similar work in the NT.

Rootstock trial:

The development of rootstock/scion combinations was scheduled to finish after the 2000 season but an almost 100% fruit loss due to fertiliser burn in 2000 plus the death of trees resulting in poor replication has relegated this portion of the project to a lower priority. The differences in flowering and tree size in 2000 were not significant. The data from 2001 was also poor.

Nutrition and irrigation benchmarking

The rambutan (*Nephelium lappaceum* L.) is a large tropical tree that is a member of the Sapindaceae family along with longan and lychee. The rambutan is believed to be native to West Malaysia and the islands of western Indonesia and as such prefers a tropical climate (within 15^{o} of the equator) on land below about 500 m elevation. The climate should be warm and wet with few dry periods. The soil should generally be well drained and slightly to moderately acidic.

In Australia the fruit has grown in popularity and a considerable area has been planted with rambutan. The rambutan industry was valued at $2.7 million in 1995 with the bulk of the crop being grown in North Queensland. The industry in the NT is smaller but provides approximately a third of the value of the national industry. In the NT, rambutan is an emerging tropical fruit crop and is profitable to grow with a market value in 1994 of $800,000 with an estimated 12,000 trees planted (140-200 ha). The majority of this development has occurred without a rambutan growing culture or knowledge.

Irrigation is a necessary part of production in the wet-dry tropics. In the NT, the dry season (May to September) is the main period during which irrigation is required. Irrigation rates and frequency varies from orchard to orchard. The wet season (October to April) although reliable in terms of total rainfall, is still a period in which irrigation is required due to in-season variability.

Previous work has developed an irrigation management strategy for rambutan production in the Darwin region. This strategy includes a droughting period in an attempt to improve flowering. Delayed or poor flowering and poor fruit retention is of major concern to growers in the NT, who are able to exploit a market window which exists in November - December, prior to the onset of fruit availability in Queensland. Better control of flowering and fruiting through improved irrigation management would greatly facilitate income stability for growers in the NT and Queensland.

Another area of poor knowledge was on tree nutrition. Much of the literature on fertiliser management of rambutan is practical in nature with few clear scientifically based experiments. Previous work conducted in the NT produced in 1997 the most comprehensive guidelines of rambutan fertiliser requirements to date. That study suggested that in commercially produced rambutan in the NT, the chief demands were for nitrogen, potassium and phosphorous.

The previous work conducted in the NT, while excellent, was still very basic in comparison with studies on other tree crops in Australia. There was still a lack of information on fertiliser management, in particular the effect of frequency of application during fruit development. This is something best established in the field. Thus there is much to be gained by monitoring growers with differing practices.

The aim of this project is to improve our understanding of nutrient and irrigation management in rambutan, with particular emphasis on management through the fruit filling stage. This should lead to improved yield and fruit quality with more efficient use of fertiliser and irrigation inputs and hence increased profitability. Since the monitoring and reporting components of the project are closely linked with industry participation, the adoption of new findings will hopefully be rapid and lead to improvements in productivity.

In 1998 a large number of rambutan growers in the NT were requested to take part in this project. Fourteen agreed. Their properties plus the Coastal Plains Horticulture Research Farm (CPHRF) of the NT Department of Business, Industry and Resource Development were used to conduct the nutrition study of the project. The irrigation part of the project was conducted on nine grower properties and CPHRF.

The field methodology for the nutrition trial consisted of soil and leaf sampling from each property four times a year. The sampling times were set so that significant tree behaviour (flowering, flushing, etc.) could be represented. At each sampling a methodology developed by earlier workers was used to reduce variability both in the field and in the laboratory.

The results of the laboratory analyses were then combined with yield data and other records of tree vigour to develop for each nutrient a suitable range in the leaf and in the soil. To develop these recommended ranges, various techniques were used that had proven useful in other crops. The new ranges are shown in Table 1. Work by Lim et al. was conducted in the Darwin region in early to mid 1990s while the work of Watson and Dostle was published in the mid 1980s, based on sampling conducted in north Queensland.

The best method to prove the efficacy of the new ranges is through linkage to improved yield. Unfortunately this was very difficult to do in this project, due to unusual environmental effects. The 1998 season was very promising until a cyclone crossed near Darwin in early December, causing a very large fruit drop with estimates of crop loss ranging between 30 to 75%. In 1999 and 2000 there were some cold and dry spells just during and after flowering that limited pollination and caused the abortion of young fruit.

However, analysis of other records of tree and soil health and balance indicate a large amount of general improvement. The information on improvement was shared through group discussions and one-to-one sessions. The growers were keen to be involved and openly discussed management practices. There were over 20 meetings with the grower group throughout the time of the project, which is something of a record for such a small group.

This project also showed that there were no significant differences between fertigation and broadcasting of granular fertiliser to provide rambutan with its nutrient requirements. So decisions on method of fertiliser application can be more readily made based on economic or time-constraint criteria rather than on effect on tree vigour or yield.

The significant environmental impact on this project showed yet again that not enough is known about the influence of the environment, especially the harsh environment in the NT, on flowering and fruiting of rambutan. More work needs to be done in this area.

The part of the project on irrigation management was more like an extension exercise than a strict scientific study. On each of the ten selected properties, three trees of the same variety, age and vigour were selected as representatives. At each tree (not always the same trees as those sampled for soil and leaf nutrition) a range of soil moisture monitoring devices were installed. Each property installed a water meter in a lateral irrigation line. Rain gauges and temperature and relative humidity loggers were also installed at most of the properties.

All ten properties were visited once a week, the soil moisture was measured and each monitor tree was visually assessed for gross phenological behaviour (flushing, mature/resting, flowering, fruiting). The *Tinytalk* II loggers were downloaded fortnightly. At each property the latest soil water readings were relayed to the grower. Wherever possible, the grower accompanied the researcher during the data collection and was introduced to the mechanics and theory of measuring and interpreting soil water status.

Most growers were quite good at managing water inputs to their rambutan trees. An analysis of actual inputs versus recommended inputs indicated that once the rain had stopped in mid April all the growers were close to the recommended level. However the level of inputs was still significantly ($p<0.01$) different from recommended. Most of the difference occurred during the stressing period. In 2000 the flowering was later than normal which could explain the higher inputs; however it is those very years of poor flowering that stressing is meant to benefit most

Table 1. A comparison of recommended soil and leaf nutrition levels/ranges for Rambutan in northern Australia

Nutrient	Leaf			Soil	
	Lim et al.	**Watson and Dostle**	**New**	**Lim et al. Mean Value**	**New**
N	1.54 - 1.68%	2.0 - 2.6%	1.9 - 2%	0.10%	0.08 - 0.17%
P	0.21 - 0.23%	0.2 - 0.3%	0.2 - 0.25%	63.3 mg/kg	75 - 220 mg/kg
K	0.69 - 0.77%	0.7 - 0.9%	0.6 - 0.8%	0.97 cmol (+)/kg	70 - 130 mg/kg
Ca	0.68 - 0.77%	1.0 - 1.5%	0.64 - 0.74%	4.43 cmol (+)/kg	400 - 750 mg/kg
Mg	0.41 - 0.48%	0.25 - 0.35%	0.23 - 0.31%	3.32 cmol(+)/kg	100 - 275 mg/kg
Mn	104 - 150 mg/kg	60 - 100 mg/kg	85 - 240 mg/kg		
Cu	16 - 25 mg/kg	10 - 15 mg/kg	7 - 19 mg/kg		
B	43 - 55 mg/kg	40 - 50 mg/kg	30 - 58 mg/kg		
Fe	77 - 98 mg/kg	35 - 81 mg/kg	40 - 95 mg/kg	56.05 mg/kg	20 - 70 mg/kg
Zn	43 - 54 mg/kg	30 - 35 mg/kg	14 - 28 mg/kg	2.84 mg/kg	1 - 5 mg/kg
Cl	0.11 - 0.13%	< 0.2%	0.02 - 0.06%	8.54 mg/kg	3 - 8.5 mg/kg
S	0.16 - 0.17%	0.12 - 0.28%	0.15 - 0.2%	15.09 mg/kg	8 - 56 mg/kg
EC				0.05 mS/cm	0.04 - 011 mS/cm
pH				6.27	5 - 7
HCO_3				155 ppm	65 - 185ppm
Org. Carbon				2.08%	1.5 - 2.6%

SUBPROGRAM: Subtropical Fruits

PROJECT: Irrigation/Nutrition Management Guidelines for Date Palms

Project Officers: **A. Nesbitt and S. Nagarajah**

Location: Alice Springs

Objectives:

To establish water use guidelines for date palms.

To establish leaf and soil nutrient guidelines for date palms.

Very little information exists on detailed irrigation and nutrition guidelines for producing quality dates. This project aims to establish some tentative guidelines on water use requirements for date palms grown in central Australia, as well as suggest leaf and soil nutrient standards for date production.

Irrigation

Irrigation was not monitored as closely this season as had been done previously. Past seasons' results have shown that the 30 cm tensiometer showed the greatest fluctuation but was consistently kept above –20kPa. Also, with the 90-cm tensiometers showing readings between –35kPa to –20Kpa, the soil was obviously well watered throughout the season. It is known that mature date palms may use 27 ML/ha of water per annum. However, it is not known whether these tensiometer values correspond with actual crop water requirements.

Nutrition

Leaf and soil samples were collected throughout the season to monitor fluctuations in essential nutrients. This information will also be used to establish nutrition guidelines for date palms in central Australia. Table 1 shows the range in values of some of the nutrients monitored in leaf and soil samples over the past three seasons. Large fluctuations are seen in many of the soil samples due to seasonal timing of the sample as well as fertiliser applications, particularly for nitrogen and phosphorus.

Table 1. Ranges of nutrient levels found in leaf and soil samples (Oct 1999 – Nov 2001)

Nutrient	Soil range (Top 30 cm)	Leaf range, %
Nitrogen	2.6 – 14, mg/kg (Nitrate N)	0.97 – 1.26
Phosphorus	2 – 29, mg/kg (Olsen P)	0.05 – 0.094
Potassium	0.32 – 0.68, cmol(+)/kg	0.43 – 0.71
Calcium	3.4 – 3.9, cmol(+)/kg	0.62 – 0.95
Magnesium	1.8 – 2.3, cmol(+)/kg	0.14 – 0.26
Sodium	0.04 – 0.19, cmol(+)/kg	$2x10^{-3}$ – $5x10^{-3}$

A similar sampling regime is expected to continue for one more season, at which time modifications to the above values will allow us the make tentative recommendations for optimum soil and leaf nutrient status for date production.

Project:	**Stone Fruit Evaluation in the Alice Springs Region for the 2001 Season**
Project Officers:	**D. King, N. Isgro, D. Salter, I. Broad, A. Nesbitt and G. Kenna**
Location:	Arid Zone Research Institute (AZRI) and Ti Tree Research Farm

Objective:

To enhance the commercial profitability and productivity of stone fruit in the Alice Springs region.

Introduction:

At present, there are no commercial plantings of stone fruit in the Alice Springs region. There are however indicators that potential markets for central Australian stone fruit may exist in the Northern Territory and interstate.

Research plantings of stone fruit have been established at AZRI in the past. Initially these plantings grew well and produced satisfactory crops; however they eventually became unthrifty and had a short life span. The rootstock used for these earlier plantings was Nemaguard. This rootstock was unable to adapt to the high pH levels of the soils, and the high soil temperatures experienced through the summer period.

Method:

New plantings were established at AZRI in 1996, 1997 and 1998 consisting of peaches, nectarines, apricots and plums. Presently there are six varieties of apricots, five of plums, 10 of peaches, and 17 of nectarines planted. Another four varieties of apricots were planted in 1999.

A planting was also established at the Ti Tree Research Farm in 1998. This planting includes eight varieties of peaches, five of nectarines and two of apricots. This planting will come into production in 2002.

The aim of these plantings is to evaluate the potential for the commercial production of dessert stone fruit under central Australian conditions. This will include the evaluation of a range of stone fruit types and varieties with varying chill requirements on a range of rootstocks.

The main rootstock used on low chill selections of peaches and nectarines is Bright's Hybrid, (a peach/almond hybrid). This rootstock has nematode resistance and a tolerance to high soil temperatures and pH levels. Plum and apricot varieties are grown on plum rootstocks, Microbalan 29C and Marianna.

Results:

Fruit assessments, including weights, counts and diameters along with brix measurements were carried out on all varieties as in the previous year.

The 2001 season provided significant increases in yields compared with the 2000 season in all stone fruit varieties except high chill varieties, which remained stable.

The maturity of the trees, a lighter pruning regime and less thinning contributed to the high yields and quality of fruit. The capacity of the trees to carry the extra crop load and still produce quality fruit demonstrates that it is possible to produce highly marketable stone fruit in central Australia (see Figure 1.)

Peaches
In 2001 flowering occurred for low and some medium chill varieties from mid July through until mid August. Harvest commenced in late October and lasted until the end of November. Trees were harvested two to three times a week. High chill varieties flowered later and harvest was completed in mid December.

Flordaglo had the highest average yield per tree, increasing by 153% from last year. Desert Red increased by 119% and Flordagold by 96% (see Table 1). Sugar levels in all varieties assessed exceeded the

Australian standards (see Table 2). Fruit sizes were larger than in previous years in spite the heavier crop loads (see Table 3).

Nectarines
Flowering for the nectarines in 2001 was similar to the peaches (mid July to mid August). Harvest commenced in early November and lasted until the end of the month. Sundowner (6/3) had the highest yield increase per tree (183%) over the previous year.

The 'Unknown' variety increased by 143% and Sunraycer (84/16) by 141% (see Table 1). Sugar levels in all varieties assessed were well in excess of the Australian standard (see Table 2). Fruit sizes were also up on previous years (see Table 3).

Apricots
In 2001 the Trevatt variety was the only producer. Apricots need a longer period of time to establish with most trees expected to carry a light crop in the 2002 season (see Table 1).

Table 1. Stone fruit harvest 1997, 1998, 1999, 200 and 2001 (average yield per tree)

Variety	1997 (kg)	1998 (kg)	1999 (kg)	2000 (kg)	2001 (kg)
Nectarines (N) Sundowner (6/3)	2.51	15.32	14.59	38	107.5
Sunraycer (84/16)	1.14	3.52	8.35	48.4	116.8
Unknown [N]	2.46	4.06	10.61	66.5	161.5
Peaches (P) Flordagold	1.66	11.8	12.3	31.9	62.5
Flordaglo	4.24	14.66	23.24	23.2	58.8
Desert Red	0.94	12.05	9.41	41.3	90.6
Apricots (A) Moorpark Early	0	0.02	N/A	7	N/A
Trevatt	0	0.16	N/A	5.4	36
Moorpark	0	0.05	N/A	N/A	N/A

Sugar content of the fruit was measured with a refractometer. The readings, in degrees brix, also gave indications to the relative maturity of the fruit. The refractometer readings were acquired by squeezing juice from the fruit after it had been cut into sections.

Table 2. Average brix for each variety of stone fruit harvested

Variety	Brix	Aust. minimum standard*
6/3 (N)	11.9	11.0
84/16 (N)	11.6	11.0
Unknown (N)	12.4	11.0
Flordagold (P)	11.9	11.0
Flordaglo (P)	12	11.0
Desert Red (P)	12.6	11.0
Moorpark Early (A)	14.5	N/A
Trevatt (A)	14.0	N/A
Moorpark (A)	13.2	N/A

*Product Description Language: Stone Fruit: Copyright Australian Horticultural Corporation 1999

In Australia, most stone fruit is sold in single and double layer trays, usually by count (the number of fruit per package). The count refers to the number of fruit packed in a single layer tray and the diameter refers to the diameter of each cell in that tray. *

Nectarines	Large 67 mm and greater Medium 56 to 66 mm	*Peaches*	Large 70 mm and larger Medium 58 to 69 mm

Small 55 mm and smaller Small 57 mm and smaller

Table 3. Counts and diameters

Variety	Count*	Average diameter (mm)
Desert Red (P) 2001	28	66.5
Desert Red (P) 2000	28	64.4
Flordaglo (P) 2001	32	60.5
Flordaglo (P) 2000	36	59.7
Flordagold (P) 2001	25	68
Flordagold (P) 2000	28	64.6
Sundowner 6/3 (N) 2001	36	58.7
Sundowner 6/3 (N) 2000	40	54.6
Sunraycer 84/16 (N) 2001	40	55.2
Sunraycer 84/16 (N) 2000	40	54.3
Unknown (N) 2001	36	58
Unknown (N) 2000	36	56.8

*Product Description Language: Stone Fruit: Copyright Australian Horticultural Corporation 1999

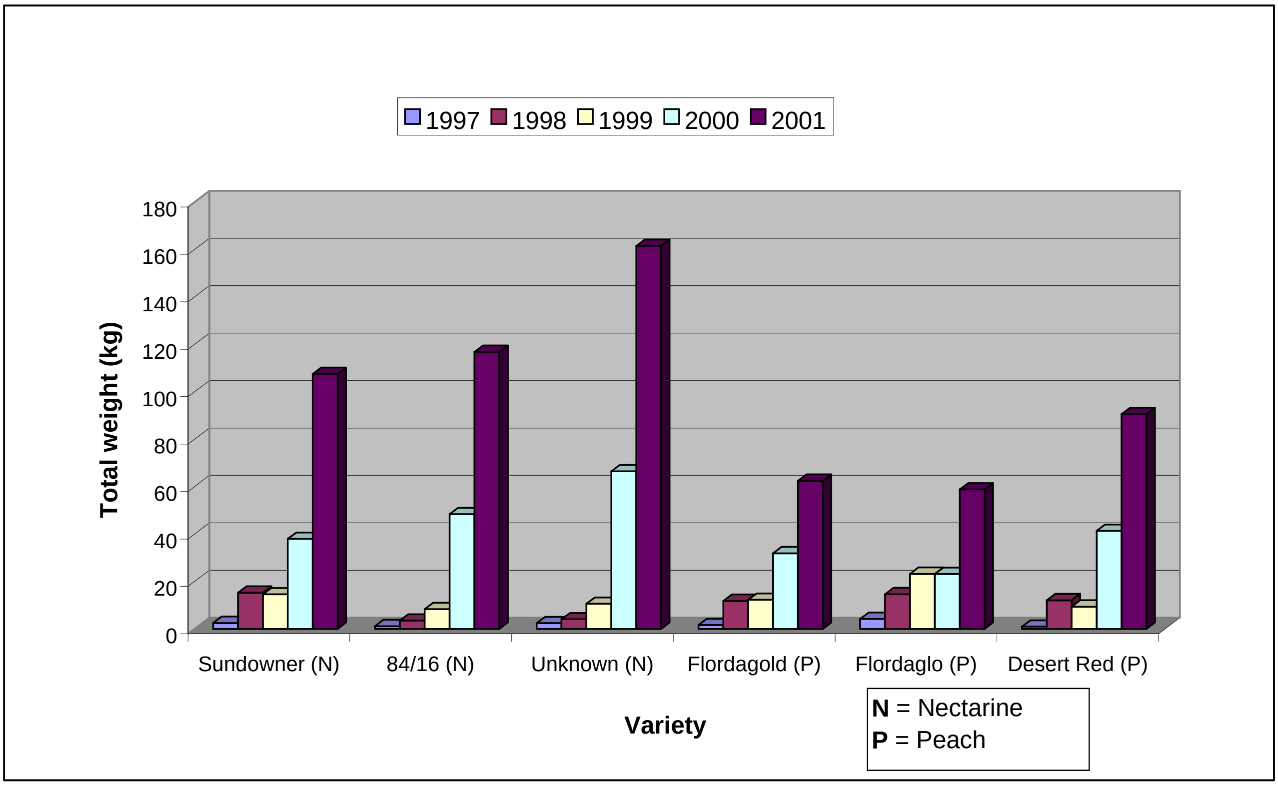


Figure 1. Average yield per tree (kg)

Results from leaf nutrient analysis in 2001 have indicated low levels of zinc throughout the planting. A zinc spray in the cooler months (June to September) may rectify the problem. Copper and calcium levels were marginal. Copper-oxy-chloride sprays have been used to overcome the copper deficiency problem. Leaf samples were collected in early December and showed that iron levels were marginal; however there were no visual symptoms.

Pest Problems
A major problem that has occurred in the past at AZRI is the amount of fruit damaged by birds as it is ripening. The use of a gas powered 'scare' gun has reduced the impact of birds on the trial however early maturing crops still sustain heavy losses. 'Bait' sprays have also been used for the control of fruit flies.

Summary

Overall, commercial yields of three varieties of medium and low chill nectarines and peaches planted between 1996 and 1998 were higher than in previous years. Three varieties of apricots planted in 1999 produced a small crop. Fruit fly infestation and severe bird damage affected marketable weights.

Future Work

Removal of high chill varieties will allow a more detailed and intense assessment to continue on selected varieties of nectarines and peaches. Collate and assess nutrition and irrigation results. Two more years of variety performance tests on apricots.

Pome fruit

Summary

Performance of the Pink Lady (planted in 1997) and the Sundowner (planted in 1998) varieties will continue to be monitored at AZRI and TTRF. Nutrition and irrigation will also be monitored in both plantings

Future Work

As apples do not come into production until five years after planting, their evaluation will need to continue for another two years.

SUBPROGRAM: Citrus

PROJECT: The National Red Fleshed Grapefruit Trial

Project Officers: **N. Isgro, D. King and I. Broad**

Location: Alice Springs Region

Objectives:

Evaluate the adaptability of new grapefruit cultivars to growing conditions in central Australia.

Assess fruit quality and yields to determine which cultivars have commercial potential for the best production in central Australia.

Red fleshed grapefruit is popular with consumers in the United States, Israel and Western Europe. The demand is also growing in the Asian region. Horticulture Australia has indicated that there is potential in the near future for Australia to export up to 100,000 tons of red fleshed grapefruit to these countries, including Japan.

A national project, funded by the Rural Industries Research and Development Corporation, has been established to introduce red fleshed selections and a white fleshed low acid cultivar, Oroblanco, into established citrus production areas and those areas with potential for citrus development throughout Australia.

Commercial selections of red fleshed varieties were introduced into Australia in 1986. Participation in a national trial has made these selections available for commercial assessment in central Australia. The South Australian Research and Development Institute is coordinating this project.

Method:

Arid Zone Research Institute
Seven clones consisting of Marsh, Oroblanco, Ruby Pink, Henderson, Ray Ruby, Rio Red and Star Ruby on two rootstocks, Carrizo Citrange and Swingle, have been planted. They are arranged in single tree plots with four replicates of each in a random design.

Planting took place in July 1995. Fifty six trees were planted, with a surrounding guard row of lemon and orange cultivars.

Ti Tree Research Farm and Murray Downs Station
Demonstration plantings have been established at these locations. The plantings at Ti-Tree Research Farm and Murray Downs consist of one tree of each cultivar on each of the two rootstocks (Carrizo Citrange and Swingle).

Data collection
Data was collected on fruit maturity, which includes recording of Brix and Brix/Acid ratios, fruit characteristics, juice percentages, counts, weights, diameters, seed counts, rind thickness and comments on external blushing and internal pigmentation.

Grapefruit maturity is determined by calculating the sugar/acid ratio of the fruit. The national standards state the minimum sugar/acid ratio for grapefruit to be 5.0: 1. One reason for this is to prevent the sale of immature fruit.

Juice percentage is an important aspect of maturity and marketability of the fruit. The national standards set the minimum content of juice at no less than 33%.

Results and Discussion:

Arid Zone Research Institute
A summary of the 2002 yield data for each of the seven varieties on both rootstocks planted at AZRI is shown in Table 1. Average yields are shown for each cultivar on each of the two rootstocks (Carrizo Citrange and Swingle). The yield data shows that the season has been relatively consistent with little differences shown between rootstocks. Rio Red was again the best performer out of the red varieties on both rootstocks. The performance of Star Ruby on either rootstock has improved quite a lot in respect of internal and external fruit quality. Fruit numbers have increased compared with other seasons.

Table 1. Average fruit counts and weights per tree for the 2002 season, AZRI

	Swingle			Carrizo Citrange		
Variety	**Av. fruit count**	**Av. fruit weight (g)**	**Av. yield per tree (kg)**	**Av. fruit count**	**Av. fruit weight (g)**	**Av. yield per tree (kg)**
Marsh	344.5	300	108.7	339.3	317	113.3
Oroblanco	300	462	145.8	264	329	91.3
Ruby Pink	331	330	115	410.3	303	130.9
Henderson	364.3	259	99.2	336	314.3	105.5
Ray Ruby	321.3	245	82.8	321	267	90.2
Rio Red	420.3	309	136.7	411.3	278	120.1
Star Ruby	381.3	271	108.6	353	300	111.5

A summary of the 2002 brix sugar/acid data for AZRI is provided in Table 2. The data indicates that all varieties had reached maturity at the start of sampling in early April. The lowest ratio recorded was Star Ruby on the rootstock Swingle at 5.0:1. The highest ratio was Oroblanco on the rootstock Carrizo Citrange at 16.8:1. The results show that all cultivars grown on the rootstock Carrizo Citrange with the exception of Ray Ruby seem to mature earlier than cultivars grown on Swingle (see Table 2). The second sampling was carried out in mid May, the data indicates that all scion/ rootstock combinations had increases in sugar/acid ratios.

Data of this season shows all varieties on both rootstocks met or exceeded the juice percentage standards by early April. There were very few differences between rootstocks on both sampling dates except for Ray Ruby, which produced 7% more juice when grown on the rootstock Swingle (see Table 2).

The results also show for the first time that Oroblanco grown on both rootstocks at AZRI met and exceeded the juice percentage standards in early April. Nutrition management may have played a vital role in achieving this. Starving the tree of nitrogen has a major influence on rind thickness. Reducing the rind thickness will generally increase juice content.

Table 2. Maturity data for 2001-2002 season, AZRI

	8/04/2002				13/5/02			
	Juice %		Brix/Acid ratio		Juice %		Brix/Acid ratio	
Cultivar	**Swingle**	**Carrizo Citrange**	**Swingle**	**Carrizo Citrange**	**Swingle**	**Carrizo Citrange**	**Swingle**	**Carrizo Citrange**
Marsh	40.8	40.4	5.6	6.2	45.9	44.0	5.7	6.3
Oroblanco	34.8	33	13.3	17.9	37.2	38.7	13.6	16.8
Ruby Pink	42.3	41.3	5.7	6.1	47.6	46.9	6.2	6.4
Henderson	41.1	41.1	5.1	6.1	48.7	47.6	5.5	6.2
Ray Ruby	44.3	38.8	5.9	5.2	48.6	44	6.3	5.3
Rio Red	42.1	41.7	5.8	6	46.7	46.7	5.9	6.2
Star Ruby	45.5	42.5	5	5.9	48.9	46.7	5.9	6.5

*Note: The Australian juice percentage standard is 33% and the sugar acid ratio is above 5.0:1

Ti Tree Research Farm

Similar data was collected for TTRF as for AZRI. A summary of the 2002 yield data for TTRF is shown in Table 3. Yield data of this season has been consistent with little differences shown between rootstocks. Rio Red was again the best performer out of the red varieties on both rootstocks.

Table 3. Average fruit counts and weights per tree for the 2002 season, TTRF

	Swingle			Carrizo Citrange		
Variety	**Fruit count**	**Average weight (g)**	**Total weight (kg)**	**Fruit count**	**Average weight (g)**	**Total weight(kg)**
Marsh	380	371.5	141.2	345	364.2	132.3
Oroblanco	178	584.3	109.5	175	616.2	113.5
Ruby Pink	193	430.5	193	37	645.5	25.1
Henderson	#	#	#	521	292.1	160.2
Ray Ruby	446	313	147	266	316	88.5
Rio Red	561	350.5	207	502	362.5	191.5
Star Ruby	344	356.2	129	#	#	#

A summary of the 2002 maturity data for TTRF is shown in Table 4. Oroblanco grown on both rootstocks and Ruby Pink grown on Carrizo Citrange, did not reach the juice of 33% by late March. One reason that Ruby Pink on Carrizo Citrange did not perform as well compared with other years was the lack of fruit set which may have been caused by abnormal weather conditions, such as hot winds at the time of fruit set. All other varieties grown on both rootstocks were well above the maturity standards by late March with little difference between rootstocks.

All varieties exceeded the sugar acid ratio by late March especially Oroblanco grown on both rootstocks. However, the rind thickness was greater than 14 mm and this contributed to the low juice content. The second analysis was carried out in early May. Results show a steady increase in juice percentage in most varieties on both rootstocks. Again Oroblanco on both rootstocks did not reach the set juice standard of a 33% minimum. Ruby Pink grown on Carrizo Citrange did exceed the juice standard of 33% by early May. Sugar acid ratios continued to increase, especially for Oroblanco grown on Carrizo Citrange which reached a sugar acid ratio of above 20:1.

Table 4. Maturity data for 2001-2002 season, TTRF

	27/03/2002				8/5/2002			
	Juice %		Brix/Acid ratio		Juice %		Brix/Acid ratio	
Cultivar	**Swingle**	**Carrizo Citrange**	**Swingle**	**Carrizo Citrange**	**Swingle**	**Carrizo Citrange**	**Swingle**	**Carrizo Citrange**
Marsh	40.9	38.6	6.2	6.4	44.7	45.9	7.8	7.2
Oroblanco	26.9	30.1	13.4	10.8	30.1	30.9	18.1	21.8
Ruby Pink	41	29.7	6.6	6.1	48.2	36.1	6.9	6.5
Henderson	#	44.7	#	5.9	#	52	#	6.3
Ray Ruby	43.4	41.8	6.4	6.9	52.6	51.8	6.8	7.2
Rio Red	38.8	37.1	5.6	6.1	47.8	44.2	6.8	6.8
Star Ruby	42.1	#	5.8	#	49.5	#	6.6	#

*Note: The Australian juice percentage standard is 33% and the sugar acid ratio is above 5.0:1

Pests
The occurrence of both the citrus leaf miner (*Phyllocnistis citrella*) and large populations of Queensland fruit fly (*Bactrocera tryoni*) reduces net productivity and overall fruit quality. Pest management programs are being implemented to deal with these pests, particularly the citrus leaf miner.

The fruit piercing moth (FMP) (*Othreis* spp.) in the Ti-Tree area has not caused much damage this season due to a dryer summer. A solution to manage FPM has not yet been found, but research continues at QDPI to find a solution. FPM problems occur about once in every six years.

Future work:

This is the final year of the national red fleshed grapefruit trial. After four years of assessment enough data has been collected to conclude this study. A detailed report will be produced outlining all results. The grapefruit planting will be reduced and only selected trees will remain for any future research and presentation purposes. Irrigation, nutrition, pest management and general maintenance will continue on the remaining trees.

Summary:

From the data collected during four seasons, recommendations can be made to industry on which scion/rootstock combination are best suited to central Australian conditions. Comparisons can also be made on all other aspects of fruit maturity and internal and external characteristics. It can also be pointed out what varieties are mature when market demand is at its highest and what other niche markets are available.

PROJECT: Evaluation of Navel Oranges, Lemon and Mandarin Cultivars

Project Officers: **I. Broad, N. Isgro, D. King and D. Salter**

Location: Alice Springs Region

Objective:

Evaluate the adaptability of navel orange, lemon and mandarin cultivars to growing conditions in central Australia

Navel oranges
As navel oranges entered their second year of production the performance of individual varieties became a little more evident. Most maturity levels were well above Australian standards in both brix sugar/acid ratios and juice content. However, results obtained from both Toc and Barnfield Summer navels show a slower rate of maturity when compared with the other varieties. This may be due to the fact that Toc and Barnfield

Summer navels are later maturing varieties. The data collected this season would suggest it is quite possible to produce navel oranges of high quality that can be harvested as early as April, which coincides with market demand because supply to domestic markets is limited from March to June.

Assessments were also made on the average yields for each scion rootstock combination. The combinations were assessed according to their age. Four-year trees and two-to-three year trees were assessed separately.

First let us assess the older scion rootstock combinations. The results obtained this season gave a clear picture of the performance in dividual varieties. Both Leng navel on Swingle and Washington navel on Troyer Citrange had comparatively high fruit counts. Leng navel on Swingle had the highest overall fruit count. However Toc Summer navel on Troyer Citrange produced noticeably less fruit, which may be due to the fact that it is a later maturing variety. It is also interesting to note that both Leng navel on Swingle and Washington navel on Troyer Citrange produced over 100% more fruit than last season.

Comparisons were also made between the younger varieties. All three Scion rootstock combinations produced clearly different fruit numbers. Washington navel on Citrange produce substantially more than both Leng navel on Swingle and Barnfield Summer navel on Trifoliata. However, it is expected that Leng navel on Swingle will catch up with Washington navel on Citrange by next season and perhaps produce similar results to those seen in the more mature varieties. The performance of Barnfield Summer navel on Trifoliata is not expected to change dramatically because the rootstock used in this trial -"Trifoliata"- has already been trialled in central Australia and its performance was poor.

Lemons
The results this year showed that all lemon varieties reached or exceeded the Australian juice content minimum of 30% by late March. However, though all varieties fared well, Lisbon on Citrange, Fino on Citrange and Lisbon on Troyer Citrange clearly were the best overall performers. Domestic markets are often in short supply from December to April and the data collected suggests selected lemon varieties are meeting juice requirements as early as February. However, fruit harvested at this early stage in most cases is still quite green in appearance.

Assessments were also made on the average yields for each scion rootstock combination. The lemon scion rootstock combinations were also assessed according to age. Mature trees and young trees were assessed separately.

The data obtained this season from the mature lemons shows Eureka on Citrange to be the highest overall fruit producer when compared with Lisbon on Troyer Citrange and Lisbon on Citrange. However, though this is true, it is interesting to note that the fruit obtained from Eureka on Citrange was much smaller than that of the Lisbon combinations. There was little difference between Lisbon on Citrange and Lisbon on Troyer Citrange.

The results from the younger trees showed Lisbon on Citrange as the best overall performer producing approximately 25% more than both Fino and Verna grown on the same rootstock. The results also show the fruit from Lisbon on Citrange is the largest of the three varieties.

Pest and disease

It became evident during last season that if not appropriately managed, the Queensland fruit fly (*Bactrocera tryoni)* could have a serious effect on fruit quality and overall net productivity. This season however, appropriate methods of control were implemented, and very little if any damage has occurred.

The citrus leaf miner (*Phyllocnistis citrella)* was also detected last season and continues to be a concern, however at this stage it seems to pose little threat to the overall quality or productivity of the citrus varieties.

Future Work:

Assessment work will continue on most of the above varieties for the next two years.

The NSW Department of Agriculture has recently established a sugar/ acid ratio of 4:1for lemon varieties. One reason for this requirement is to prevent immature fruit reaching the market place. Brix and acid testing will now be incorporated into existing maturity tests conducted at AZRI so that comparisons can be made.

Obtain some meaningful data from the mandarin trial for presentation in 2003.

PROJECT: Industry Development Strategies for the Northern Territory Citrus Industry

Project Officers: J. Mansfield, M. Connelly and G. McMahon

Location: Various

Objective:

To assist the Northern Territory citrus industry to develop and implement industry development strategies.

The 2002 Australian Citrus Growers' Conference

The 54th Australian Citrus Growers' conference was held at the Carlton Hotel, Darwin, from 14 to 20 April 2002. This meeting is held annually and the venue for it is rotated around the various citrus growing States/Territories of Australia. The conference was arranged by a local organising committee in conjunction with the Australian Citrus Growers Incorporated (ACG) and Horticulture Australia Limited (HAL). The local organising committee was comprised of members of the Northern Territory Citrus Growers Association (NTCGA), staff from a professional conference-organising company, and staff from the Northern Territory Department of Business, Industry and Resource Development (NTDBIRD).

The primary aim of the conference is to host the annual meeting of the ACG. However, as a number of growers and people associated with the citrus industry are assembled for this meeting, it provides an opportunity to organise speakers and field trips to inform the participants of issues relevant to the Australian citrus industry. In addition, during the conference week, various social functions are organised for the delegates. Also it was anticipated that while participants were in the Territory they might be interested in undertaking tourist activities and in finding out about horticultural investment opportunities.

In the planning for the conference, the organising committee decided to adopt the following strategies:

1. Examine the running of previous national conferences to determine which aspects of them could be applied to the forthcoming conference.

2. Develop a questionnaire to get feedback from potential participants to the forthcoming conference to determine what their expectations of it would be if they attended.

As part of strategy 1, a delegation of Northern Territory industry and departmental representatives attended the 2001 ACG conference in Renmark to gather ideas for the upcoming conference and prepared a report. The report contained ideas on how various aspects of the conference could be organised based on observations and discussions conducted in Renmark. These included the registration process, functions, speaker sessions, field trips and meetings. In addition, a desktop analysis was done of the evaluation of the 2001 conference conducted by the organising committee. The organisers circulated a post-conference questionnaire to participants to evaluate various aspects of the conference. A summary of the results of the Renmark conference questionnaires was obtained and some information relevant to the organising of the 2002 conference obtained.

To address strategy 2, a questionnaire was developed based around the key question "What is your reason for attending the conference?" The other questions in the questionnaire then investigated various aspects of this key question. This questionnaire was circulated nationally using the citrus industry development officers in the various citrus producing regions of Australia. About 130 questionnaires were returned.

Based on the information gathered in the planning phase, the local organising committee established a theme for the conference speakers and field trips - "The Territory - Gateway to Asia". The aim of the program of speakers was to outline the requirements and the opportunities for marketing Australian produced citrus in the Asian region and the role that Darwin and the Northern Territory could play in providing infrastructure such as railway access and port facilities. In addition, the aim was to highlight how a northern Australian citrus industry, and other horticultural industries in the region, could complement other Australian citrus producing regions.

About 150 participants including growers, industry, departmental, agency and accompanying persons from all over Australia attended the conference.

The following key points came out of the conference:

- The potential of tropically grown citrus, particularly red grapefruit, lemons and limes was acknowledged by participants.

- The flavour of the red grapefruits, particularly the cultivar Henderson, was considered to be excellent by a number of participants.

- Due to the difference in production times between the northern and southern regions, growers in established citrus producing regions are not threatened by production in tropical Australia. They are actively supporting the new areas, highlighted by their large attendance at the conference. The new areas are seen as a benefit to the Australian citrus industry because they increase the period of time that Australian citrus can be supplied to the market.

- Some participants acknowledged the opportunities for the citrus industry offered by the Alice to Darwin railway and the port facility.

- Speakers at the conference highlighted the threat to the citrus industry from pests and diseases that could be introduced because of the close proximity of the Northern Territory to Asia.

- An evaluation by independent evaluators showed that a majority of the participants rated the conference highly. A report on the conference will be written for Horticulture Australia Limited.

The Northern Territory Citrus Growers' Association's Industry Development Plan

A working group of members of the NTCGA and DBIRD staff met for a strategic planning session on 16 October 2001. Dave Mundy and Liz Easton facilitated the meeting. The purpose of the plan is to identify the direction the NTCGA will take in the next five years by defining a vision statement and goals.

From this meeting, Version 1 of the NTCGA Industry Development Plan was developed. This was completed in June 2002 and circulated. In addition to the Plan, which contained the industry goals, two background documents were prepared summarising a range of industry issues. The plan identified the following goals:

1. Improve grower understanding of pests and diseases and introduce monitoring programs for better quality fruit.

2. Improve quality, yield and timing through nutrition and irrigation control for market windows.

3. Develop food safety program for Northern Territory citrus.

4. Look at the market opportunities for locally produced citrus, set up a marketing group and call for tender for a company to undertake a study on collecting market information.

5. Develop a strategy for self-funding of the Northern Territory Citrus Growers' Association.

6. Identify suitable land and water resources for the sustainable development of the NT citrus industry

The vision statement developed at this meeting was: “The Northern Territory citrus industry will have a cohesive and viable group producing volumes of quality fruit under our brand/logo for niche markets domestically and overseas”.

The strategic plan was to be revised in July 2002.

PROJECT: Management Strategies for Citrus in the Northern Territory

Project Officers: **M. Connolly, M. Weinert, S. Bellgard and J. Mansfield**

Location: Various

Objectives:

Determination of a range of management strategies for various regions.

Adoption of management strategies by industry.

Insect monitoring and adoption of IPM
Fruit from some of the grapefruit trees has good internal quality. However, the external appearance of the fruit is often blemished because of insect damage, which is causing a high level of reject fruit and reduced prices at the market. During the 2000/2001 citrus season, some growers received $25 per carton of grapefruit but were told that they could have received $40 if the fruit had better external appearance.

In September 2001, the Northern Territory Citrus Growers' Association (NTCGA) asked the Director of Resource Protection, DBIRD (formerly DPIF) for suggestions to develop strategies with it for training growers and establishing commercial insect scouts.

The Director suggested the employment of a scout to monitor citrus orchards and to be paid through contributions from growers, the NTCGA and federal funding bodies. DBIRD entomologists would assist with the training of the scout. The NTCGA executive will assess the proposal before presenting it to its members.

In recent years, Megan Connolly, the DBIRD entomologist in Katherine, has been regularly visiting five citrus properties in the Katherine/Mataranka region collecting baseline information on insect populations present. She also visits five other properties in the region on an irregular basis. She is currently planning to visit five or six citrus properties in the Darwin region on a regular basis to collect baseline information. A scouting company could use this data to initiate operations.

Several workshops were conducted to assist train citrus growers in insect monitoring and control. In June 2001, workshops on integrated pest management (IPM) in citrus were conducted in Darwin and Katherine. A commercial IPM expert, Dan Papacek from "Bugs for Bugs", conducted the workshop in Darwin. The workshop in Katherine was more detailed. In addition to a presentation by Dan Papacek, staff from the Entomology Branch provided training for growers on insect monitoring and principles of IPM. In addition, Andrew Beattie from the University of Western Sydney gave a presentation on the use of petroleum oils for pest management in horticultural crops on 16 April 2002.

Orange stem pitting virus monitoring
An amendment notice for the gazetting of orange stem pitting (OSP) virus as a notifiable disease under the Northern Territory of Australia *Plant Diseases Control Act* was published in October 2000. This amendment was made in an attempt to protect the developing NT citrus industry from the introduction of OSP from other States such as Queensland. Prior to the introduction of this amendment notice it was permissible to bring citrus material into the Northern Territory from Queensland. However, the NTCGA had concerns that the disease may already be present in the NT. They requested that orchards be checked for the presence of the disease.

In response, Pat Barkley, National Citrus Industry Development Manager, Auscitrus was asked to conduct surveys of citrus orchards while she was in Darwin for the Australian Citrus Growers' Conference. Pat visited orchards in the Katherine and Darwin regions with plant pathologists from NAQS and DBIRD from 22 to 24 April 2002. No symptoms of citrus canker or greening (huanglongbing) were seen. The main diseases encountered were greasy spot and gummy pitting. The survey was particularly looking for OSP strains of citrus Tristeza virus, which may have been imported into the NT on citrus trees from Queensland. However, while no symptoms of OSP were observed, the survey was considered inconclusive, because access was permitted only to orchards where growers had given prior permission and also most of the citrus species grown in the Top End (grapefruit and lemons) can be infected but not show symptoms. Pat prepared a report on her findings.

PROJECT: Improved Citrus Products for the Northern Territory

Project Officers: J. Mansfield, J. Bright, R. Renfree and A. Maddern

Location: Katherine Research Station

Objectives:

Identify cultivar/rootstock combinations suitable for both existing and potential markets when grown in various regions of the NT.

Growers optimise their returns by producing fruit of the required cultivar and quality for the intended market.

Evaluation of mandarin cultivars in the Top End – Katherine
Early cultivar assessments of mandarin production in Katherine were not encouraging due to poor management, which resulted in low flowering, low and erratic yields. Recent trials have shown promising results on other citrus with modification of management, using moisture stress to enhance flowering and fruit thinning to increase yield and individual fruit size. The NT citrus industry has requested that mandarin cultivars be assessed again as this would increase the options available to growers as to what to grow and how to increase market opportunities. Since previous assessments were made, a number of new cultivars and cultivars from climates similar to Katherine have been made available. There is virtually no Australian production of mandarin/tangor types for the months of January, February and March. Early maturing cultivars at Katherine could be harvested in February and March. This trial will focus on 26 cultivars, nine of them bred by CSIRO. Imperial and Murcott have been included in the trial as reference cultivars.

Method:

Twenty-six mandarin cultivars grafted onto Swingle rootstock were planted at the Katherine Research Station in 2001/2002. Treatments are single tree plots replicated four times. Cultivars included:

CSIRO 2762	Imperial
Cemintard	Fremont
CSIRO 2107	CSIRO 2103
CSIRO 2552	Fortune
Temple	CSIRO 2105
CSIRO 2127	Topaz
Can Sanh	Encore
CSIRO 2350	Nova
CSIRO 2728	Sunburst
Clausallina	Daisy
CSIRO 2336	Quit Dong
Fallglo	Murcott
Emperor	Algerian Clementine

Other mandarin seed from various countries will be planted as guard trees.

Evaluation of citrus cultivars in the Top End – Grapefruit
While the grapefruit industry was traditionally based on fruit with white internal colour, in recent times fruit with red internal colour has been released for commercial production. Red-fleshed grapefruit is expected to be popular in Australia because it is visually more appealing and some cultivars are more palatable than the traditional white-fleshed cultivars.

Method:

There are two plantings of grapefruit at the Katherine Research Station:

Planting 1
The planting consists of five super red cultivars: Star Ruby, Rio Red, Flame, Ray Ruby and Henderson, which were planted on a range of rootstocks during 1992-1995. The rootstocks were C35 citrange, Swingle and Trifoliata. However, not all scions were grafted onto each rootstock. There is one tree of each of the following combinations: Flame on Swingle (planted 14/7/92 and budded October 1995); Ray Ruby on C35 (planted 14/7/92 and budded 15/12/92); Rio Red on C35 (planted 14/7/92 and budded 11/8/94); Rio Red on Swingle (planted 14/7/92 and budded 11/8/94); Star Ruby on C35 (planted 14/7/92 and budded 11/8/94); and Star Ruby on Swingle (planted 14/7/92 and budded 15/12/92). There are two trees of Henderson on Trifoliata (planting date unknown) and Ray Ruby on Trifoliata (planted 14/7/92 and budded 15/12/92) and three trees of Henderson on Swingle (planted 14/7/92 and budded 15/12/92) and Ray Ruby on Swingle (planted 14/7/92 and budded 15/12/92). There are no trees of Flame on either C35 or Trifoliata, Henderson on C35, Rio Red on Trifoliata or Star Ruby on Trifoliata.

Planting 2 (This planting was made as part of the National HRDC red-flesh grapefruit cultivar trial)
Eight cultivars of grapefruit were budded on to two different rootstocks and planted in randomized, single tree plots in 1995. The eight cultivars are Marsh, Oroblanco, BCP3-Ruby type grapefruit, Henderson, Ray Ruby, Rio Red, Star Ruby and Flame (established eight months later). The rootstocks used were Swingle Citrumelo and Carrizo Citrange. Originally, there were four replicates of each cultivar/rootstock combination. However, the planting was rationalised in January 1999 with half the trees removed. This then left two replicates of each combination except for Flame on Swingle where there was one replicate and Oroblanco on Swingle where there were three replicates.

Measurements
Fruit was picked from both plantings for the determination of fruit quality in late January, early March, early April and early May. The main harvesting of fruit occurred following the May evaluation. The number of fruit and total fruit weight were recorded to calculate average fruit weight.

Results and Discussion:

Planting 1
The average yield of the scion/rootstock combinations ranged between 135 and 190 kg as shown in Table 1. The average fruit weight ranged between 415 g and 515 g. Interpretation of the results needs to be treated with some caution due to the small number of replications of each combination. This is especially important, as so many combinations have failed.

The current market standard for grapefruit include a juice content above 33% (NSW Grading, Packaging and Labelling Requirements). The readings for all cultivars/rootstocks combinations were above this standard when determined in early March. In fact juice content in late January was acceptable for Henderson on Swingle and almost acceptable for Ray Ruby on C35 (Table 2).

The current market standards for grapefruit also include a brix: acid ratio of 4.5:1 (NSW Grading, Packaging and Labelling Requirements). The brix: acid ratio was above 6:1 for all cultivars/rootstocks combinations when determined in late January. As the season progressed the ratio increased for all rootstock/scion combinations (Table 3).

Table 1. Total yield and average fruit weight for grapefruit Planting 1

	Rootstocks					
	C35		**Swingle**		**Trifoliata**	
Cultivar	**Yield (kg)**	**Average weight (g)**	**Yield (kg)**	**Average weight (g)**	**Yield (kg)**	**Average weight (g)**
Flame	No trees					
Henderson	No trees		190	427.6	190.5	515.8
Ray Ruby	135.72	466.4	162.4	415.2	173.0	425
Rio Red	No trees					
Star Ruby	No trees					

The values are an average of one, two or three trees depending on the combination.

Table 2. Juice content (%) at various sampling times for Grapefruit Planting 1 (n/a – no assessment)

a) C35 Rootstock

Cultivar	**Late January**	**Early March**	**Early April**	**Early May**
Flame	No trees			
Henderson	No trees			
Ray Ruby	32.6	42.8	45.3	45.7
Rio Red	No trees			
Star Ruby	No trees			

b) Swingle Rootstock

Cultivar	**Late January**	**Early March**	**Early April**	**Early May**
Flame	No trees			
Henderson	33.7	44.5	46.6	46.1
Ray Ruby	n/a	44.2	48.5	48.6
Rio Red	No trees			
Star Ruby	No trees			

c) Trifoliata Rootstock

Cultivar	**Late January**	**Early March**	**Early April**	**Early May**
Flame	No trees			
Henderson	n/a	42.8	46.3	47.5
Ray Ruby	n/a	40	44.35	46.45
Rio Red	No trees			
Star Ruby	No trees			

Table 3. Brix:acid ratio at various sampling times for Grapefruit Planting 1 (n/a – no assessment)

a) C35 Rootstock

Cultivar	**Late January**	**Early March**	**Early April**	**Early May**
Flame	No trees			
Henderson	No trees			
Ray Ruby	6.3	7.2	8.2	9.3
Rio Red	No trees			
Star Ruby	No trees			

b) Swingle Rootstock

Cultivar	**Late January**	**Early March**	**Early April**	**Early May**
Flame	No trees			
Henderson	5.6	7.8	8.1	8.9
Ray Ruby	n/a	7.1	7.8	8.6
Rio Red	No trees			
Star Ruby	No trees			

c) Trifoliata Rootstock

Cultivar	**Late January**	**Early March**	**Early April**	**Early May**
Flame	No trees			
Henderson	n/a	6.05	6.95	8.4
Ray Ruby	n/a	6.5	7.05	8.0
Rio Red	No trees			
Star Ruby	No trees			

Planting 2

The average yield of the scion/rootstock combinations ranged between 15 and 216 kg. The trees have mainly recovered from heavy pruning in 1999. The average fruit weight ranged between 413 g and 1,079 g. The heaviest fruit was again produced by Oroblanco. There is no significant difference between rootstocks based on yield or fruit weight. Interpretation of the results needs to be treated with some caution due to the small number of replications of each combination (Table 4).

Unlike last season there is no trend or significant difference between rootstock in juice content. The cultivar Oroblanco had very low juice (max. 21.1%). While the juice content was highest in early April, there was no significant difference in the amount of juice between harvest dates. (Table 5).

The brix: acid ratio was above 6:1 for most cultivars/rootstocks combinations at all sampling times. In the previous season, the ratios were higher on the swingle rootstock at both sampling times. However, this was not the case this season with no discernible trends or significant differences (Table 6).

Table 4. Total yield and average fruit weight for Grapefruit Planting 2

	Rootstocks			
	Carrizo		**Swingle**	
Cultivar	**Yield (kg)**	**Average weight (g)**	**Yield (kg)**	**Average weight (g)**
Flame	25.1	530.9	56.2	562.1
Henderson	166.5	456.5	116.3	542.2
Marsh	182.6	513.2	130.9	568.1
Oroblanco	159.7	1079.1	65.4	921.6
Ray Ruby	216.2	465.5	152.7	455.9
Rio Red	151.8	524.2	112.0	491.9
Ruby	88.9	512.7	96.9	453.5
Star Ruby	48.7	412.6	15.6	612.4

Table 5. Juice content (%) at various sampling times for Grapefruit Planting 2 (n/a – no assessment)

	Rootstocks							
	Carrizo				Swingle			
Cultivar	**Late January**	**Early March**	**Early April**	**Early May**	**Late January**	**Early March**	**Early April**	**Early May**
Flame	n/a	31.8	40	27.2	32.5	41.6	45.8	44.3
Henderson	n/a	36.8	40	41.2	n/a	37	45.7	38
Marsh	35.3	35.4	41.7	35.2	n/a	37.5	42.9	37.4
Oroblanco	n/a	15.4	9.4	n/a	21.1	19.1	17.8	n/a
Ray Ruby	n/a	42.2	45.4	41.9	n/a	44.7	48.9	43.5
Rio Red	n/a	35.9	41	33	35.6	41.4	46.4	45.1
Ruby	31.6	27.7	29.5	31	n/a	42.7	46.7	42.9
Star Ruby	33	34.2	38.7	33	n/a	34.4	38	35

Table 6. Brix: acid ratio at various sampling times for grapefruit Planting 2 (n/a – no assessment)

	Rootstocks							
	Carrizo				Swingle			
Cultivar	**Late January**	**Early March**	**Early April**	**Early May**	**Late January**	**Early March**	**Early April**	**Early May**
Flame	n/a	6	7.8	8.1	5.2	6.7	7.5	8.5
Henderson	n/a	6.4	7.5	8.2	n/a	6.4	7.8	8.3
Marsh	8.2	8.1	7.3	8.1	n/a	6.4	7.5	8.3
Oroblanco	n/a	13.4	18.5	n/a	10.7	15.1	20.4	n/a
Ray Ruby	n/a	6.8	8.2	9.2	n/a	6.7	8.2	8.9
Rio Red	n/a	7.7	9.6	9.8	5.7	7.2	7.8	8.0
Ruby	6.6	6.6	8.4	8.7	n/a	8.7	9.4	8.7
Star Ruby	6.4	7.6	8.7	9.7	n/a	7.2	8.2	8.7

Evaluation of citrus cultivars in the Top End – Lemon

There is a strong interest in growing citrus in the Top End. This is because the high temperature during the time when fruit is maturing makes the region ideal for quality, early fruit production. By controlling the growth patterns of the trees, lemons can be produced in January to March when prices on the domestic market are highest. There is also potential for export of lemons into South-East Asian markets such as Japan for the restaurant industry.

Method:

At Katherine Research Station four cultivars Meyer, “Taylor” Eureka, “Prior” Lisbon and Villa Franca, were budded on 15/12/92 to Benton rootstock planted on 14/7/92. Fino and Verna were budded on 15/4/93 to Benton rootstock planted on 14/7/92. For each cultivar, except Meyer, there are two trees. For Meyer there is only one tree.

Fruit was picked from both plantings for the determination of fruit quality in late January, early April and early May. The main harvest of fruit was after the May evaluation. The number of fruit and total fruit weight was recorded to calculate average fruit weight.

Results and Discussion:

The lemon trees were heavily pruned during late 1999 so as to reduce size and improve internal branch structure. The trees failed to flower and fruit during the 2000 season and did not fruit in the 2001 season except for a small amount of fruit on the Meyer tree. However, the trees have recovered from the pruning and now have good canopy structure and produced fruit in the 2001/2002 season.

The yields ranged between 16.6 and 129.1 kg per tree (Table 7). There are no significant differences between the trees; however the variation (within and between varieties) is so high and replication is so small that meaningful statistical analysis cannot be conducted.

The current market standard for lemon includes a juice content above 20% (NSW Grading, Packaging and Labelling Requirements – Summer Fruit)). The readings for all cultivars were above this standard at all sampling times (Table 8). While there are no standards for acid content in lemon, there is only a limited market for the "sweeter" lemons such as Meyer. Table 9 shows that again Meyer had the lowest content of acid.

Table 7. Total yield and average fruit weight for lemon cultivars on Benton rootstock

Cultivar	Yield (kg)	Average weight (g)
Eureka	64.7	183.3
Fino	16.6	201.8
Lisbon	101.5	187
Meyer	129.1	169
Verna	45.4	162.3
Villa Franca	17.7	166.8

The values are an average of one or two trees depending on the combination.

Table 8. Juice content (%) at various sampling times for lemon cultivars on Benton rootstock (n/a – no assessment)

Cultivar	Late January	Early April	Early May
Eureka	42.3	45	35.4
Fino	44.6	44.6	39.3
Lisbon	43.5	44.6	37.4
Meyer	50	n/a	n/a
Verna	39.5	39.2	32.7
Villa Franca	46.6	46.4	26

Table 9. Acid content (%) at various sampling times for lemon cultivars on Benton rootstock (n/a – no assessment)

Cultivar	Late January	Early April	Early May
Eureka	3.9	3.1	5.5
Fino	4.2	3.3	6
Lisbon	4.0	3.1	5.9
Meyer	2.5	n/a	n/a
Verna	3.8	3	5.9
Villa Franca	4.1	3.1	3.6

Evaluation of citrus cultivars in the Top End – Pummelo

The pummelo is considered to be the most suitable of the citrus species for tropical conditions. However, the greatest obstacle to the development of large-scale pummelo production in Australia is the lack of thin-skinned, high quality cultivars. The introduction of known overseas cultivars has been severely restricted by quarantine regulations. Citrus canker, citrus dieback and greening, navel orange worm, citrus mal secco, orange stem pitting (OSP) strain of tristeza and citrus fruit borer are all potential quarantine risks that could be introduced through imported propagating material. Therefore, it is very difficult and expensive to import cultivars. However, seeds from some overseas cultivars have been introduced. The selections currently grown in Australia have been chosen from these seeds, as well as from local promising seedlings. Pummelo, unlike most other citrus, produces seedlings that are genetically different from the parent. This is unfortunate in that seeds cannot be used as a reliable means for importing known cultivars from overseas. However, it is possible to select superior cultivars within Australia since a wide range of plants with different characteristics is available, but most are inferior.

Method:

Planting 1

Seedlings of six pummelo lines introduced from overseas by CSIRO Merbein, Victoria were planted at Ti Tree Farm on 11 June 1987. The seedlings of CS43 Blood red pummelo showed the most potential with five seedlings (CS43-4, CS43-5, CS43-6, CS43-8 and CS43-9) producing fruit with some potential. “CS43” is the CSIRO Division of Horticultural Research identification number. The lines were originally from the Horticultural Research Laboratory, USDA, Orlando. The figure after the "CS43" is the seedling number.

Budwood from these five seedlings was used to propagate more trees for further evaluation at Katherine Research Station. Each selection was grafted onto Trifoliata and Swingle rootstocks and one replicate of each combination was planted in June 1994.

Planting 2

Seed of a red-fleshed pummelo type from Israel was sown at KRS in September 1996, and transferred to the field in July 1997. A total of 46 trees from this material have been established on their own roots. Seed from a low acid pummelo type (Leeman pomello) from Darwin was also sown at KRS from which 24 trees were field planted in May 1997 on their own roots.

Results:

In Planting 1, all but three of the trees have died from termite damage and other causes. The three remaining trees became unthrifty and were skeletonised in 2001 in an endeavour to increase their vigour.

The trees in Planting 2 are yet to start producing fruit. They have been set back in previous years by sunburn and termite damage. However, they are now starting to increase in canopy size.

Discussion:

The 2001/02 season produced some high quality fruit as discussed in these reports. However some of the yields were low and most were extremely variable between trees within varieties. This problem can only be overcome by improving replication within the projects.

These projects however, have shown that citrus crops can be produced in the Katherine Region. Hopefully the rootstock trials will help improve yields for the benefit of the NT citrus industry.

PROGRAM: Vegetables and Ornamentals

SUBPROGRAM: Vegetables

PROJECT: Japanese Taro Observation Trial 2002

Project Officers: **M. Traynor and P. Hopkinson**

Location: CPHRF

Objectives:

Compile basic yield and quality data under local conditions.

Compare the yields of different sized corm propagules.

Provide a sample of harvested corms to the Project Coordinator for quality assessment.

Identify any crop management issues that may need addressing.

Introduction:

The need to diversify vegetable production was identified as a priority by Asian vegetable growers and is included in current business plans for the Vegetable Research Program. Although the large "Bunlong" taro variety is produced locally, the small-cormed Japanese type is unknown to growers. A project currently run by the University of Central Queensland has identified seasonal demand and supply of this taro in Japanese markets. Australia has an excellent opportunity to export to Japan during the seasonal production shortfall of the major Asian suppliers. Planting material was supplied to DBIRD to participate in initial production trials, which are being conducted on a range of sites in NSW, Queensland and the CPHRF in Darwin.

Method:

Planting material
Japanese taro (*Colocasia esculenta* var. *antiquorum*) cultivar "Ishikawa wase"

Propagule size ranges (10-20 g) (20-30 g) (30-60 g) (100-300 g)

Trial design
Raised beds 50 cm wide and 30 cm high.

1.0 m between beds.

0.3 m plant spacing.

Propagule sizes planted separately in non-replicated plots.

Corms planted 10–20 cm into hills.

Management:

Basal fertiliser
CK55 at 100 g/m of row

Super at 100 g/m of row

Gypsum at 200 g/m of row

Injection fertiliser
0 – 1 month: corm emergence/no injection

1 – 4 month: 320 kg N/ha
213 kg K/ha
100 kg P/ha

4 – 6 month: 80 kg N/ha
120 kg K/ha
48 kg Ca/ha

Irrigation
2 x 20-cm high flow T-Tape per bed.

Watering time was 30 minutes per day for early growth, increasing to 30 minutes twice per day after corm initiation.

Planting date: 01/12/2001

Harvest date: 28/5/2002 to 2/7/2002

Pest and disease control was not required for the trial.

Results:

The crop was planted and grown during the hot and humid conditions of the wet season with fairly regular monsoon rainfall from January through to March. With weekly injections of fertiliser, growth was fast and vigorous. Vegetative growth peaked in early April, about four months from planting. In early May, plant leaves were turning a paler colour and leaf petioles were starting to bend over. These visual signs indicate that corm development is complete. By mid May, leaves were dying back and progressive harvests commenced in late May. Grading was done on corm weight only, and excluded other external characteristics.

Table 1. Average corm number and weight for each propagule size

Grades									
Propagule	**Small (<20 g)**		**Medium (20-40 g)**		**Large (40-60 g)**		**X-Large (>60 g)**		**Mother corm**
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Weight (kg)
10-20 g	22	0.26	24	0.71	15	0.75	7	0.61	0.22
20-30 g	26	0.30	28	0.81	16	0.78	9	0.79	0.22
30-60 g	34	0.38	35	0.95	34	1.65	12	1.18	0.32
100-300 g	90	1.14	83	2.37	53	2.76	34	4.21	0.46

Although the sample plant numbers were low, the increase in total yield with larger propagules is evident. The percentage of unmarketable yield for each propagule size was not significantly different. If only medium and large grades are suitable for export, approximately 40% of harvested yield was unmarketable.

Table 2. Average yield per plant

Grades									
Harvest date	**Small (<20 g)**		**Medium (20-40 g)**		**Large (40-60 g)**		**X-Large (>60 g)**		**Mother corm**
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Weight (kg)
04/06/2002	16	0.20	20	0.64	14	0.73	8	0.75	0.22
11/06/2002	24	0.30	21	0.63	15	0.74	7	0.58	0.24
18/06/2002	21	0.23	23	0.67	14	0.69	4	0.38	0.21
25/06/2002	19	0.22	19	0.57	14	0.70	7	0.60	0.21

Table 2 shows that progressive weekly harvests of seven plants during June showed no noticeable difference in yield. This suggests that optimum harvest maturity for a December planting is at six months and that delays in harvest will not affect yield.

Observations and comments:

- With suitable irrigation, all year production is possible under local tropical conditions. This would allow targeting any export market window.

- Yearly selection of propagules for the desired shape from the harvested crop may help reduce the variation in corm shape that was evident in this trial.

- All corms were quite strongly attached together when plants were lifted from the bed. They were separated manually, adhering roots removed and then washed with high-pressure water. On a large scale, mechanisation to separate and clean the corms would be required.

- While plant spacing of 0.3 m may be suitable for smaller propagules, it should be increased to allow for potential yield increases of larger propagules.

- Samples of marketable corms from the eight trial sites around Australia were sent to the Project Coordinator in Sydney to assess appearance and eating quality. Our corms from the CPHRF trial were rated highly.

PROJECT: Bamboo Research 2001/2002

Project Officer: **M. Traynor**

Location: CPHRF and two grower sites

Objectives:

Trial irrigation and fertiliser inputs and scheduling for optimum shoot production for D. asper and D. latiflorus conducted on established planting at CPHRF and two growers sites.

Thinning rate investigations on grower sites with D. asper and D. latiflorus in relation to shoot size and yield.

Correlate leaf nitrogen levels with shoot sap nitrate levels to develop a simple nutrient monitoring system for growers.

Trial shoot covering techniques to maximise eating quality.

Background:

The Horticulture Division in conjunction with the University of Central Queensland is participating in a three-year project funded by the Australian Centre for International Agricultural Research (ACIAR) titled "*Improving and maintaining productivity of bamboo for quality timber and shoots in Australia and the Philippines".* Although the project includes research on timber production, the Division will concentrate its effort on the production of quality vegetable shoots.

Research will be conducted on the two species identified as having strong potential as vegetable shoot producers. These are *Dendrocalamus asper* and *Dendrocalamus latiflorus*. Along with the established trial planting at CPHRF, the two largest commercial plantings of these two species were selected as additional trial sites. The sites belong to Mr. Richard Kingsley of Bamboo Planet Earth Pty. Ltd. (D.asper) and Mr Phil Vivian of Pal Enterprises. (D.latiflorus).

Method:

All experiments on the three trial sites are fully randomised with three replicates. Treatments combine irrigation, fertiliser and thinning trials for the purpose of defining management practices for optimum shoot yield and quality.

Irrigation treatments

1. A 100% irrigation schedule based on mean monthly daily evaporation-replacement using a crop factor of 1.0 initially. Irrigate twice daily.

2. A 50% of treatment 1 inputs. Irrigate twice daily.

3. Droughting treatment from April to September. Irrigate to 100% from October. Test the need for dry season irrigation.

All treatments are monitored twice weekly with tensiometers and once a week with the Diviner Moisture Probe to a depth of 1 metre. All water inputs metered and recorded.

Fertiliser treatments

1. A 100% treatment. To test the assumption that leaf nitrogen concentration of 3% is optimal for photosynthesis and therefore production. Nitrogen inputs per hectare are calculated using the nitrogen response equation for bamboo developed by the project's principal investigator Prof. D. Midmore. The objective is to maintain 3% N in the leaf.

2. A 25% of fertiliser inputs as determined for treatment 1.

3. A 200% treatment. Double treatment 1 fertiliser inputs.

Experiments use NPK nutrient ratio of 4:1:3 or similar. Fertiliser applications with before and after leaf analyses are conducted before, during and after the shooting season. Leaf sampling for %N and shoot sap nitrate testing will be conducted concurrently across treatments.

Thinning treatments

1. Thin yearly to four each of one, two and three-year old culms. (4-4-4)

2. Thin yearly to four of one, two of two and two of three-year old culms. (4-2-2)

3. Thin yearly to two each of one, two and three-year old culms. (2-2-2)

These treatments will test the effect of standing culm density and culm age on shoot size and yield. Shoots selected to grow into culms will have a year ID marking. The yearly dry season thinning of treatments will be conducted in June.

Shoot covering

Small-scale observation trials are planned on practical methods of excluding light from developing shoots. Measurements will be taken of quality parameters such as bitterness levels, texture and internal and external appearance.

Progress:

The second year of the project has commenced and all experiments have been established on the three trial sites. Irrigation systems to meet the requirement of the experiments were established and monitoring sites were installed in March 2002. After sprinkler flow tests were completed, the irrigation treatments commenced in May 2002. Fertiliser treatments commenced after initial leaf and soil nutrient testing of all sites in October 2001.

The initial thinning of all treatments was done in late 2001 and the diameters of all remaining culms were recorded to test uniformity. Shoot harvest and shoot selection was conducted during the 2001/2002 wet season. The first thinning operation to maintain the specified standing culm densities was done in July 2002.

Fertiliser and irrigation response data is being collected. The first shoot yield data will be recorded during the 2002/2003 wet season.

Project participants agree that the full evaluation of experiments will take longer than the current three-year timeframe. It is hoped that the project will receive further funding from ACIAR to fully achieve its objectives.

SUBPROGRAM: Ornamentals

PROJECT: Expanding the Product Range of Heliconia and Ginger Flowers

Project Officers: **D. Marcsik, M. Hoult, M. Gosbee, M. Connelly, C. Ford and E. Laska**

Location: BARC and CPHRF

Objectives:

To have industry partners "on farm" and market testing, new and diverse heliconia and ginger flower selections by December 2002.

To screen the large NTDBIRD Curcuma gene pool for suitable commercial cut-flower products by July 2002.

Introduction:

The cut-flower market is continually seeking new and diverse flowers to complement existing products. The development of new flower lines can be as simple as open-pollinated seedling selection or as complex as controlled breeding. Each strategy has a role in developing new tropical cut flowers. The importation of heliconia rhizomes into Australia is prohibited because of a potential danger of introducing exotic diseases of bananas, which are a close relative of heliconia. This has left very few options for industry to source new cultivars. One easy approach is the selection of open-pollinated (OP) seedlings.

Curcuma is a large genus within the Ginger family that offers good prospects for development. A number of Thai species have recently been developed for commercial production supplying markets in Japan and Europe. Many species within the genera occur in a similar climate to that of the Top End of the NT and the one endemic species in north Australia warrants some development.

Method:

Heliconia

OP seed was collected from mature plants of *H. psittacorum* cvs: Suzi, Parakeet, Lady Di, Andromeda and Lizette; *H. rostrata*; *H. platystachys* and *H. chartacea* cvs: Sexy Scarlet and Sexy Pink. Fruits were soaked in water for a week and the flesh was removed and the cleaned seed air-dried and dusted with fungicide. Seed were then sown in trays containing a steam-pasteurised peat - perlite mix. Once seedlings had attained two to three leaves they were potted on into 2 litre poly bags into a steam-pasteurised peat, sand and composted pine bark media. Seedlings were planted out in December 1999 in rows 3 m apart and 2 m within the row. Selection of better seedlings followed visual assessment by an industry group where unattractive individuals were culled and promising seedlings screened for vase-life.

Curcuma

Dormant rhizomes and non-dormant potted plants of *Curcuma* accessions were established at BARC Horticultural block in 2001 in raised beds 1.2 m apart. Row spacing depended on species and/or cultivar and ranged from 30 cm, 60 cm to 120 cm. Fertiliser was applied pre-plant at 500 kg/ha N: P: K 14:14:12 and 500 kg/ha dolomite. Side dressing was done every six weeks at 100 g/m^2 of N: P: K 14:14:12 during the growing season (October to April) along with foliar application of micronutrients three times in the season. Irrigation was applied via drippers and at rates close to 100% of daily evaporation. Soil moisture was monitored with tensiometers. Some accessions were established in full sun and under 70% shade, while others were under shade only. Observations were made on basic phenology, yield and vase-life. During the later part of 2001-02 flowering season the Cut-flower Growers Group took a field walk when promising accessions were identified for further release

Results:

Heliconia
From a total of 84 OP *H. psittacorum* seedlings, the industry group selected nine for further evaluation. These are being grown under licence on commercial farms for market testing. In addition to the OP *H. psittacorum* seedlings, some selections from other *Heliconia* species were also made for further evaluation (Table 1).

Table 1. Open-pollinated *Heliconia* seedling selection, CPHRF, 2001

Species	Female parent	No. of seedlings planted	No. seedlings selected	% OP seedlings selected
H. psittacorum	Lizette	6	1	15
	Andromeda	8	0	0
	Lady Di	6	3	50
	Parakeet	12	4	30
	Suzi	52	1	2
H. rostrata	-	7	2	30
H. platystachys	-	13	0	0
H. chartacea	Sexy Pink	1	1	100
	Sexy Scarlet	15	3	20

Curcuma
The most promising accessions identified by industry included two of *C. roscoeana* cv. Jewel of Burma (CU4 and CU24); *C. australasica* (CU11); *C. thorelli* cv. Chiang Mai Snow (CU21); *C. alismatifolia* cv. Red (CU32); *Curcuma* species (CU48) and *C. aurantiaca* cv. Rainbow curcuma (CU63) (Figure 1). The best of the accessions for cut-flower was *C. australasica* (CU11) with excellent vase-life (more than 21 days), long stem and adaptability to growing in full sun. Previous screening of Curcuma accessions was reported in the 2000-01 Horticulture Technical Annual Report (Technical Bulletin No. 299).

Table 2. Preliminary evaluation of *Curcuma* accessions, BARC 2001-2

Species	Common name	Cultivar	Accession No.	Plant No.	Yield	Mean head length (cm)	Mean stem length (cm)	Vase-life	
								Age[a]	Vase[b]
C. flaviflora	-	-	CU 49-54	6	>10	9	3	5	12
Curcuma sp.	-	-	CU 56	1	6	17	21	14	26
Curcuma sp.	-	-	CU 57	1	12	21	8	7	11
Curcuma sp.	-	-	CU 59	1	2	16	16	-	-
Curcuma aurantiaca	Rainbow curcuma	Purple Top	CU 61	1	11	18	11	8	12
Curcuma aurantiaca	Rainbow curcuma	-	CU 62	1	16	14	10	6	10
Curcuma aurantiaca	Rainbow curcuma	-	CU 63	1	13	17	11	8	11
Curcuma aurantiaca	Rainbow curcuma	-	CU 64	1	2	16	6	5	8
Curcuma X	Hybrid	-	CU 65	1	3	25	19	9	16
Curcuma sp.	-	-	CU 68	1	6	17	7	10	20
Curcuma aurantiaca	Rainbow curcuma	-	CU 69	1	9	21	10	6	8

a = Average number of stems/plant; b = Average number of days to not saleable (first signs of ageing); c = Average number of days not suitable for vase (aging >35%); all accessions grown in shade.

Figure 1. Curcuma accessions identified by industry for further release

Figure 2. Highest ranked *Euphorbia milii* accessions for horticulture traits

Figure 3. Highest ranked *Euphoriba milii* accessions by industry demand

PROJECT: Commercialisation of New *Euphorbia* Hybrids

Project Officers: **D. Marcsik, M. Hoult, M. Connelly and R. Aiton**

Location: BARC

Objective:

Facilitate the introduction and release of new and diverse Euphorbia milii hybrids to benefit the nursery industry of the NT

Method:

Over a three-year period several accessions were sourced from suppliers in Thailand and brought through post-entry quarantine. On release, accessions were grown at the BARC nursery and evaluated for horticultural potential. Desirable traits were ranked by three experienced horticulturists, concurrent with industry screening and release of propagules of interest (see Table 1 and Figures 2 and 3).

Results:

Results are presented in Table 1.

Discussion:

The Thai hybrids of *Euphorbia milii* represent a new product for the local nursery industry. Prospects are encouraging for developing a range of cultivars for marketing interstate. The total number of accessions so far introduced is only a fifth of the known cultivars available in Thailand, where over 200 have been bred and selected. The variation in commercial traits is large (see Table 1) and local nurseries will need to determine what traits are of importance for their given markets and select cultivars accordingly. Interestingly, the most favoured accessions, as determined by industry demand for propagules, were predominantly red-flowered and with large bracts (see Table 1).

Table 1: Ranking of *Euphorbia* x *milii* accessions for horticultural traits (score per trait is average for three assessors where 1=poor and 5=excellent)

Accession No.	Branching suckers	Flower intensity	Compact	Bract size	Exposed flowers	Size of thorns	Grand score	Ranking	[a]Industry ranking	Bract colour
EU1	3.3	3.7	4.3	1.0	3.3	2.3	18	5	3	Red
EU2(=EU43)									4	Pale pink bands w/h dark bands
EU3									4	Pale lemon w/h pink tinge
EU4									6	Blotchy pink
EU5(=EU22)	4.0	4.7	4.7	2.7	4.7	2.7	23	1	6	Pale lemon w/h green band
EU6	2.0	3.0	2.7	3.7	3.3	2.7	17	6		Blotchy pink w/h green band
EU7	2.0	3.3	1.7	2.7	3.7	2.3	16	7		Apricot w/h blotchy pink
EU8(=EU14)	1.7	3.7	2.0	3.0	4.0	2.0	16	7	7	Veined apricot
EU9(=EU20)	3.0	2.7	3.3	2.3	2.7	2.3	16	7		Scarlet pink
EU10	2.0	3.3	2.0	3.3	4.0	2.3	17	6		Red
EU11-dead										
EU12	1.7	3.3	3.0	4.3	3.7	2.0	18	5	1	Red
EU13	2.0	4.0	2.7	3.3	4.3	2.3	19	4	5	Red pink over lemon
EU14(=EU8)										
EU15	2.3	3.3	3.3	4.0	3.3	2.7	19	4	7	Pink blotching w/h age
EU16	2.0	3.3	2.3	3.7	3.7	2.7	18	5	7	Powdery red
EU17(=EU18)	1.7	3.0	2.7	3.7	2.7	2.3	16	7	4	Pale yellow w/h pink tinge
EU18(=EU17)										
EU19	3.0	2.3	2.7	1.0	3.7	2.0	15	8		Pink red
EU20(=EU9)										
EU21	2.7	3.7	3.0	4.3	4.0	2.7	20	3	3	Red
EU22(=EU 5)										
EU23(=EU46)	2.0	3.3	2.3	3.7	3.7	2.0	17	6	7	Red w/h green band
EU24	3.0	4.3	3.7	2.0	4.3	3.3	21	2	3	Lime lemon
EU25	3.0	3.0	2.7	3.0	3.0	2.7	17	6	3	Cream
EU26	2.3	3.3	2.3	3.3	3.3	2.3	17	6		Cream w/h peachy tinge
EU27 dead										
EU28	2.7	2.7	3.0	3.0	3.7	2.0	17	6	3	Pale pink w/h darker blush
EU29	2.0	2.7	2.7	3.3	3.7	2.0	16	7	5	Lemon with pink vein
EU30	3.0	2.3	3.3	2.3	3.0	2.3	16	7	4	Lemon lime
EU31										
EU32	2.7	2.3	3.7	2.3	2.7	2.7	16	7	4	Pink w/h green band

Accession No.	Branching suckers	Flower intensity	Compact	Bract size	Exposed flowers	Size of thorns	Grand score	Ranking	[a]Industry ranking	Bract colour
EU33(=EU42)	3.7	4.3	3.3	4.0	4.0	2.0	21	2	5	Dark pink w/h green
EU34	1.7	3.3	3.3	3.3	3.7	2.7	18	5		Red
EU35	2.3	3.7	2.7	2.3	3.0	2.0	16	7		Pink with darker veins
EU36	3.0	3.7	3.3	2.7	3.3	2.7	19	4	2	Red
EU37	1.7	3.0	2.7	2.7	3.7	2.0	16	7		Red
EU38	2.0	3.0	2.7	3.3	3.3	2.3	17	6	2	Scarlet red
EU39	2.7	3.3	3.0	2.7	3.3	2.7	18	5		Pink w/h pale centre
EU40	2.7	3.3	3.7	2.3	3.0	2.3	17	6		Peach
EU41=dead										
EU42(=EU33)										
EU43(=EU2)	2.7	3.0	3.0	2.3	3.7	2.3	17	6	5	Cream w/h pink
EU44	2.7	2.7	3.7	2.0	2.3	2.7	16	7		Cream w/h thin maroon band
EU45	2.3	2.7	3.0	3.0	3.0	2.0	16	7	7	Red
EU46(=EU23)										
EU47									7	Dark pink
Mean for all accessions.	2.5	3.3	3.0	2.9	3.5	2.4	17			

[a]Industry ranking determined by the number of propagules/accession ordered by NGINT members. Note where no scores/rankings are given, plants were too young for meaningful evaluation

PROJECT: Improving Cut-flower Zingibers

Project Officers: **D. Marcsik, M. Hoult, M. Gosbee, C. Wright, M. Connelly, C. Ford and E. Laska**

Location: CPHRS and BARC

Objectives:

To quantify the heritability of commercial cut-flower traits in the genera Zingiber by July 2002

To have industry partners and NTDBIRD finalise "best bet" selections of Zingiber hybrids after "on farm" evaluation and test marketing over the next two years.

To summarise performance and role of Zingiber accessions in improving heritable, economic traits and secured, in situ conservation of this gene-pool by the term of the project.

Introduction:

In 1998, DBIRD commenced a *Zingiber* breeding project to improve and develop new cut-flower products. This followed the cut-flower industry identifying this genus as worthy of further development. Several hybrid families were generated and planted in a fully replicated trial together with parents, to determine the heritability of important traits. In collaboration with industry, selection criteria such as seasonality, yield, colour, stem length, form, vase-life and adaptability to grow in full sun were identified. By means of a number of evaluation processes, a selection of advanced hybrids was made. This report discusses the preliminary findings of the project and the first selection of promising new *Zingiber* hybrids bred for cut flowers.

Method:

Hybrid seedlings and clonal plants of each parent were planted at CPHRS, in October 1999 in a Latin row-column design consisting of 12 single datum plant replicates. In some instances low numbers of a given family and/or parent limited replications to as low as four. Plants were spaced 3 m within the row and 3 m between rows and mulched with field hay annually. All plots were irrigated with overhead sprinklers and fertilised using current industry standards.

Data was collected for two seasons on yield and for one season on stem length, vase-life, colour and form. In addition, observations were made on susceptibility to waterlogging and sunburn. Hybrids were assessed by industry in the first season of flowering based on important commercial traits through a number of meetings and field walks (Table 1).

Table 1. Selection criteria for the cut flower *Zingiber*

Criteria	Minimum standard	Priority
Seasonality	extended flowering season	Essential
Stem length	>50 cm long, shorter stem acceptable for niche market	Essential
Colour/form	range of colours	Important
Yield	>100 flowers/plant	Important
Vase-life	10 days from pick to first sign of ageing	Acceptable
Adaptability	full sun	Beneficial

Results:

Season
With regard to season, hybrid families derived from "early season" parents exhibited a shift towards early flowering. Crossing later flowering parents resulted in a trend towards later flowering in the hybrid families (Figure 1). From these preliminary results, breeding for early flowering in *Zingibers,* (an important trait identified by industry), appears attainable by crossing parents that have an early flowering season.

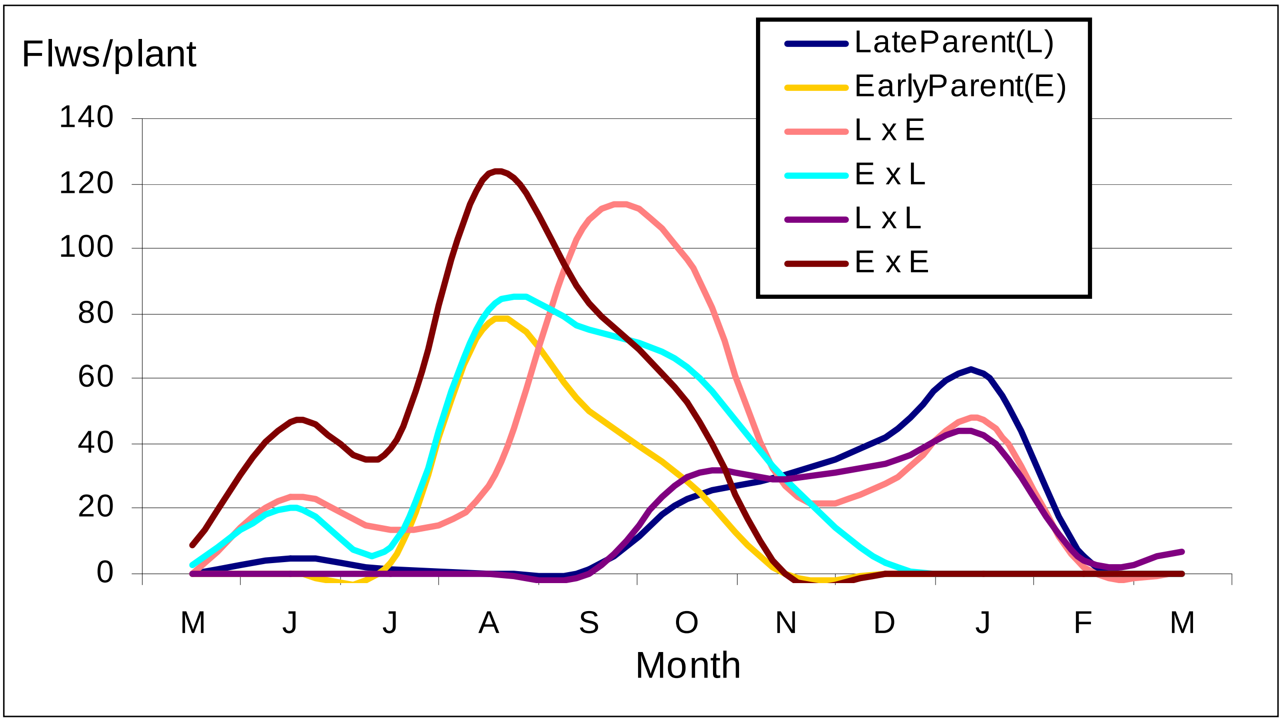


Figure 1. Influence of early and late flowering parents on the seasonality of *Zingiber* hybrids

Yield
Cumulative yields for several intra-specific hybrid families of *Z. spectabile* were superior to those of the parents. For example, when the low yielding parent "E" was reciprocally crossed with high yielding parent "A", the yield for both families was superior to the parents i.e. A x E and E x A. Likewise, yield for inter-specific families, such as A x F, was greater than that of the parents. It is interesting to note that many of the parent species, other than *Z. spectabile,* did not survive field planting but much of their progeny did. Self-crossed families exhibited a depression in yield and showed poor vigour, typical of inbreeding suppression (Figure 2).

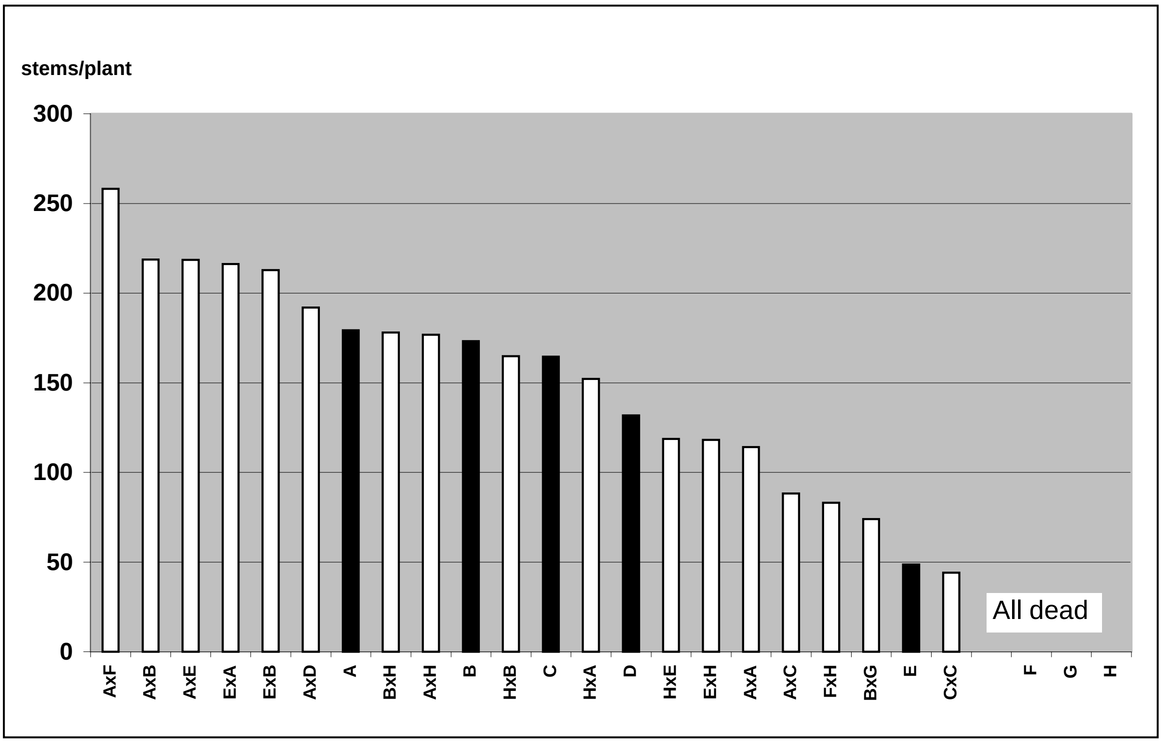


Figure 2. Hybrid family and parent cumulative yield 2000-02

Inflorescence colour, stem length and form

Darker coloured parents of *Z. spectabile* appeared to impart this trait onto progeny compared with paler coloured parents. For yellow and green forms, yellow was dominant over green in all the families derived from these crosses. Similarly, dark coloured *Zingiber* species crossed with pale coloured *Z. spectabile* species, passed on similar dark colours to progeny. Larger inflorescence heads and longer stems were evident in families where parents, exhibiting these traits were crossed. In general, most intra-specific hybrids were intermediate between their parental plants that had similar inflorescence form and stem length. For inter-specific hybrids, head form and stem length was strongly influenced by the *Zingiber* species in the inter-specific hybrid plants. The inflorescence forms of offspring were narrow and pointed with bracts closed, very much like the *Zingiber* species parent (Figure 3). Plant growth habit was strongly influenced by the inter-specific crosses with regards to height and shoot: flower ratio. These hybrid plants produced a large number of shoots and were shorter and bushy like the *Zingiber* species parents.

(a) Maternal parent (top left) and paternal parent (top right) with hybrid seedlings

(b) Maternal parent (centre) with hybrid seedlings; paternal parent in the picture on the right

Figure 3. Different inflorescence form and colour of two inter-specific *Zingiber* hybrids

Adaptability
Waterlogging and full sun conditions attributed to the poor performance and health of a number of hybrids and parents. Problems with rhizome rots and shoot collapse were experienced from poor soil aeration and an elevated water table due to above average wet season rainfall. Very little rotting was evident in hybrid families crossed with parents more tolerant of rhizome rots. Sunburn damage to foliage and inflorescence was also evident for a number families and parents. However several parents and their progeny maintained high production under full sun conditions. As for rhizome rots, sunburn damage was evident in progeny derived from susceptible parents. Highly susceptible parents and self-crossed families had very low survival in the hybrid block. In general, self-crossed progeny exhibited very poor vigour typical of inbreeding.

Promising new Zingiber hybrids
Six advanced hybrids were selected by industry for commercial evaluation. These were selected on important commercial traits as defined by industry. Provisional applications have been made for plant breeders' rights (Figure 4).

These six hybrids were propagated and released to selected commercial cut-flower growers under an "experimental testing agreement". Over the next 18 months, the performance of these hybrids will be evaluated "on-farm" and flowers market-tested to determine "best-bet" selections for commercialisation. Additional 70 advanced hybrids from the *Zingiber* hybrid block are being retained for industry evaluation over the next 18 months.

Conclusion:

The preliminary results of this project indicate that there are good prospects for further breeding of new and improved *Zingiber* hybrids for cut flowers. The success of producing inter-specific hybrids with *Zingiber* species of different forms and characteristics highlights the good prospects for developing a range of new and improved *Zingiber* hybrids

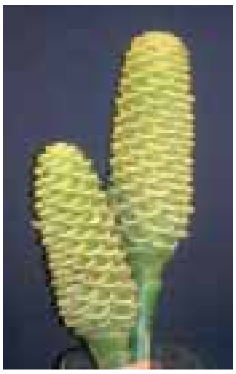
We would like to acknowledge the contribution and assistance of flower growers Jan Hintze, Peter and Troya Jettner, Kai and Lucy Hansen, Ian Hennessy, Neal Witham and Margot Race of the *Zingiber* breeding group involved in this project. Also, thanks to Patrick Lake and especially Rodney Aiton.

Darzing Dawn

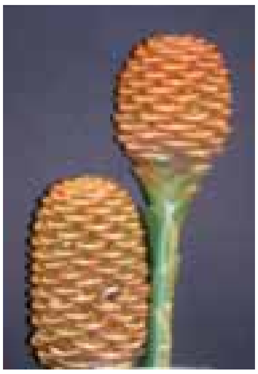
Darzing Blaze

Darzing Golden Glory

Darzing Sunsey



Darzing Pinelime



Darzing Chocolate Delight

Figure 4. 'Darzing' *Zingiber* selections

PROJECT: Enhancing Profitability of the Nursery Industry

Project Officer: M. Connelly

Location: Berrimah

Objective:

Assist the nursery IDO with the nursery industry accreditation scheme, Australia, (NIASA) guidelines.

The four accredited nurseries passed the annual audit inspections. The nursery facility at the NTU Tropical Horticulture Section was accredited on 12 June 2002. As the major accredited training centre for nursery employees, the NTU Horticulture Section will be able to convey to prospective nursery workers the benefits of the "Nursery Best Practices" guidelines set down by NIASA before entering the industry. This is a valuable step towards raising the professionalism of the nursery industry in the Northern Territory.

RESOURCE PROTECTION

PROGRAM: Resource Protection

SUBPROGRAM: Plant Pathology

PROJECT: Disease Diagnostic Service - Darwin

Project Officers: **B. Condé, R. Pitkethley, A. Daly, L. Ulyatt and I. Arao-Arao**

Location: Darwin

Objective:

To provide a plant disease diagnostic service for primary producers and the public.

Background:

The plant disease diagnostic services provided in Darwin and Katherine are a core function of the Plant Pathology Branch which forms a node of the Northern Australian Diagnostic Network (NADN) recently established by the Cooperative Research Centre for Tropical Plant Protection of which DBIRD is a partner.

Results:

In 2001-2002 a total of 608 diagnostic cases were handled in Darwin. Some interesting diseases recorded were:

- Grapevine leaf rust caused by *Phakopsora euvitis*. It was detected in July 2001 by Mr Matthew Weinert of the Northern Australia Quarantine Strategy. This was the first record of this pathogen in Australia.
- Mango scab caused by *Elsinoë mangiferae.* A heavy infection occurred of early green mature fruit in August and September 2001. The disease was apparently associated with heavy dew or fog.
- Rust of edible fig caused by *Cerotelium fici*.
- Base rot and foliage blight of bird's nest fern (*Asplenium nidus*) caused by *Sclerotium rolfsii*.
- Downy mildew of grapevine caused by *Plasmopara viticola*.
- Heart rot of cycad (*Cycas revoluta*) associated with *Fusarium* sp.
- Confirmation of a number of additional infections of banana Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*, tropical race 4 from commercial plantations.
- Anthracnose on leaves of pink passionfruit cv. Panama caused by *Colletotrichum gloeosporioides*.
- Anthracnose of grapevines in Central Australia caused by *Elsinoë ampelina.*
- Leaf spot of *Terminalia ferdinandiana* caused by *Cercospora terminaliae*.
- Leaf roll of tomato, caused by tomato leaf curl virus (TLCV-Au) – atypical symptoms with one interstate mis-diagnosis as potato spindle tuber viroid (PSTVd)
- Cucurbit mosaic virus diseases - unusually high incidence.
- 'Brown smudge' leaf spot of banana caused by *Periconiella sapientumicola*.
- Leaf rust of *Canna* sp. caused by *Puccinia thaliae*. First record of this disease in the NT.

PROJECT: Disease Diagnostic Service - Katherine

Project Officer: **S. Bellgard (0.8 FTE)**

Location: Katherine Research Station (KRS)

Objective:

Maintain a plant disease diagnostic service for the Katherine Region.

Results:

In 2001-2002, a total of 186 plant disease enquiries were received at KRS. New disease records on crop plants for the Katherine region include:

- *Asparagus officinalis* – Fern spot caused by *Stemphylium vesicarium*
- *Citrullis lanatus* – Bacterial fruit blotch caused by *Acidovorax avenae* subsp *citrulli*
- *Sesame* sp. HU 905 – Bacterial leaf spot caused by *Xanthomonas campestris* pv *sesami*

PROJECT: Plant Disease Reference Collection and Database

Project Officers: **R. Pitkethley and L. Ulyatt**

Location: Darwin

Objective:

To add to and maintain the plant disease reference collection and associated database as a diagnostic tool and a reference source.

Background:

The NT plant disease collection was initiated in mid 1960s and has been maintained and further developed since then. The plant disease herbarium at Berrimah has been unofficially designated DNAP. DNA is the international abbreviation for Darwin, and the P designates Plant Pathology

A functional database (Microsoft Access ®) was set up in 1999-2000 allowing entry of plant disease accession records to be resumed after a pause of several years. A consultant was engaged to refine the database to improve its functionality. Entry of disease accession records was resumed.

The NT DBIRD is involved in a joint project with Queensland Department of Primary Industries, under the auspices of the CRC for Tropical Plant Protection, to develop a catalogue of plant pathogens in northern Australia.

Progress:

In 2001-2002 45 accessions were added to the collection, taking the total number to 3448.

The improvements to the database have made it possible for data to be extracted and merged with the Queensland database.

The need for some further refinements to the database has been identified and will be implemented in early 2002-2003.

PROJECT:	**Establish Molecular and Other Advanced Diagnostic Techniques**
Project Officers:	**A. Daly, I. Arao-Arao and L. Ulyatt**
Location:	Darwin

Objective:

To add to and maintain molecular diagnostic equipment and tests for identifying serious plant pathogens such as banana Fusarium wilt.

Background:

The plant disease diagnostic service provided by the Plant Pathology Section was elevated in status when DBIRD became a core partner in the Cooperative Research Centre for Tropical Plant Protection (CRCTPP). One of the major initiatives of the CRCTPP was the setting up of the Northern Australian Diagnostic Network (NADN). The Darwin and Katherine plant disease diagnostic facilities together form a ‘node’ of this network. As part of the NADN establishment, the Plant Pathology Section at Berrimah is enhancing its diagnostic capability.

Results:

During 2001, the Plant Pathology Section acquired molecular diagnostic equipment to enhance its diagnostic capability, particularly with respect to banana Fusarium Wilt. The equipment was set up in the Berrimah Veterinary Laboratory with the aid of staff from the Animal Virology Section. To familiarise Plant Pathology staff with the new equipment and various methods of testing for the banana pathogen, a Fusarium wilt diagnostics workshop was held in November 2001. It was run by Dr Suzy Bentley and Ms Julie Pattemore from the CRC for Tropical Plant Protection and Dr Natalie Moore from QDPI, who are world leaders in this area. Participants included staff from DBIRD, NTU, the Northern Australian Quarantine Strategy, Department of Agriculture WA, QDPI and CRCTPP. The workshop included basic sample preparation and Fusarium culturing procedures followed by vegetative compatibility, DNA fingerprinting and PCR, the advanced diagnostic techniques for identifying the fungus.

With the use of more advanced molecular techniques for analysis of the banana wilt pathogen, the Plant Pathology Section of DBIRD is expected to become recognised Australia-wide as a proficient provider of a diagnostic service for this particular pathogen. Also, with the molecular equipment we now have, we are able to develop and adapt tests for other pathogens that may require a more comprehensive diagnosis, such as those that cause black Sigatoka in bananas.

PROJECT: Assessments and Pathogen Testing for the Nursery Industry Accreditation Scheme

Project Officers: **A. Daly, M. Connelly and S. Bellgard**

Location: Darwin/Katherine

Objective:

To assess nurseries for freedom from pathogens for the purpose of accreditation under the Nursery Industry Accreditation Scheme Australia (NIASA).

Background:

Nurseries in the Darwin and Katherine areas were visited for assessment for initial accreditation or for continuation of accredited status. Samples of soil, potting media and plant material were collected for pathogen testing at the Berrimah laboratory.

Method and Results:

Extensive testing was carried out of a shade-house at an accredited nursery in rural Darwin in August 2001 following the detection of a *Phytophthora* sp in a soil sample during a previous testing. No organisms were detected in the soil from the floor of the shade-house after amendment of the "diseased" area, or in potting media samples.

Soil and potting media samples from accredited nurseries in rural Darwin were tested for pathogens according to NIASA standards in July and August 2001 and again in June 2002. A potting media sample from an accredited nursery in Katherine was tested in March 2002. All samples were found to be free of the target pathogens *Phytophthora* spp and *Pythium* spp.

Potting media samples from a small nursery at NTU were tested in June 2002 as part of the assessment for accreditation. The nursery is used as a training facility for horticultural students, to introduce them to various concepts of the nursery industry including NIASA "best practice". The tested samples were found to be free from the target pathogens. Accreditation is pending.

PROJECT: Inspections and Indexing of Plants in Post-entry Quarantine to Intercept Diseases

Project Officers: **R. Pitkethley, B. Condé and A. Daly**

Location: Darwin

Objective:

Detect exotic plant diseases in post-entry quarantine.

Background:

Ornamentals and tropical fruits usually make up the bulk of the imported plants in the Berrimah post-entry quarantine facility. The quarantine plant pathologist makes progress inspections and full-term inspections for release.

Results:

Ornamental species predominated in post-entry quarantine in 2001-2002. Other species included cocoa and snake beans. Relatively low numbers of plants were handled during the year. The screen-house was closed in November 2001 pending a decision on its future.

PROJECT: Management System for Diseases of Mango

Project Officers: **B. Condé, R. Pitkethley and S. Bellgard (with L. Coates and others at CRC-TPP)**

Location: Darwin/Katherine

Objective:

To develop a management system for diseases of mangoes in the Darwin-Katherine regions.

Background:

Our experience in mango diseases is growing continually and is helping us to build a sounder basis for the development of a disease management system for this crop. In recent years the various forms of anthracnose and mango scab have received attention.

Method and Results:

An warning was given again in the Litchfield Times reminding growers to apply copper sprays thoroughly to reduce the damaging effects of anthracnose on their fruit. The Plant Pathology Section has been giving anthracnose warnings for several years now. As a result of extension through Agnotes, workshops by Horticulture and anthracnose warnings, damage to mango fruit has been reduced in recent years.

There were heavy post-harvest fruit losses, both in transit and at the markets last season. These losses were largely due to miscellaneous post harvest rots (not anthracnose) developing on fruit as a result of breaks in the cool chain. At times, people have confused these post-harvest rots with anthracnose. It is most important that the cool chain from harvest to market is maintained to prevent such large losses due to post-harvest rots as the fruit heats up.

We received a specimen of small young fruit with very severe mango scab from a non-English speaking grower. We diagnosed the problem as mango scab, and gave the grower the mango scab Agnote, explaining the disease and its control. He had not previously heard of mango scab. Apart from this sample, we had very few enquiries regarding mango scab. This contrasted markedly with the situation before mango scab was identified and the Agnote produced in 1997.

Several meetings were held early in 2002 in an effort to ascertain what is required by the mango industry. It was agreed with industry that DBIRD would produce an illustrated booklet on the common pests and diseases of mangoes to assist growers to identify problems in their orchards. Appropriate text and photographs were prepared and collated for the plant disease section of the booklet.

PROJECT:	**Management Systems for Diseases of Asian Vegetables**
Project Officers:	**B. Condé and I. Arao-Arao**
Location:	Darwin

Objective:

To develop a management system for diseases of Asian vegetables.

Background:

There were few vegetable growers in the post-war to the pre-1980s in the NT. They grew beans, cabbages, lettuce, and potatoes in Katherine, some vegetables in Alice Springs and tomatoes near Darwin. Rock melon growers dominated the vegetable industry in the early 1980s, largely in the greater Darwin area.

Since the late 1980s, Asian vegetables grown by Vietnamese and other Asian growers dominated the vegetable industry in the Darwin rural area. The growers were largely former fishermen or crabbers who consequently had poor horticultural skills and often could speak little English. They made up for these deficiencies through keenness to learn, determination, long hours and pure hard work. Recently a communication channel was opened through a Vietnamese with tertiary education, good scientific knowledge, good language skills and some farming experience. She has provided us with a good link with Vietnamese growers to learn about their farming problems.

Method and Results:

A poster on “Diseases of Asian Vegetables in Northern Australia” was produced with photo illustrations of 12 diseases and text. This will assist growers to identify the important diseases of the vegetable crops on their farms. Some other notable problems on vegetable farms included pollination issues with squash and root knot nematode (RKN). RKN became a problem because it built up on successive crops in the absence of any management measures.

Sweet basil
We produced an information paper on “Controlling Fusarium Wilt and Base Rot in Sweet Basil”. It described the disease and how it can be managed through the use of the resistant Nufar F1 sweet basil developed in Israel. As a result, we have had fewer growers with the basil Fusarium wilt base rot problem.

Cucurbit mosaic viruses
Mosaic viruses were again a serious problem on cucurbit crops, causing severe losses. Several long melon growers were concerned about virus infection in their crops. In response, we plan to investigate virus resistance in long melons.

Tomato diseases
This was a severe season for the leaf roll disease (caused by TLCV-Au), with levels of 60% being recorded in plants sown early in the season. This trend was similar to that in the 1970s and 1980s. Later in the season, by 28 June, after the dry cool change, the disease affected very few plants (about 5%). In contrast to the 2002 dry season, during the previous five years, levels of virus infection were much lower than 60%. This confused several growers who were not familiar with such high levels of leaf roll. Compounded with this situation were the symptoms observed in several tomato plants, which were quite different from the classic symptoms of leaf roll. They were severe symptoms resembling dieback. These circumstances unfortunately led to the incorrect interstate PSTVd diagnosis. Dr. Ali Rezaian of CSIRO Adelaide is studying the unusual tomato plants. Eventually the “dieback-like” tomato plants developed leaves with leaf curl symptoms characteristic of leaf roll (TLCV-Au). The tomato leaf roll Agnote was updated by including some of the findings from this season.

PROJECT: Management System for Fusarium Wilt of Snake Beans

Project Officers **B. Condé and I. Arao-Arao**

Location: Darwin

Objective:

To develop a management system for Fusarium wilt of snake beans.

Background:

Fusarium wilt of snake beans, caused by *Fusarium oxysporum* f.sp. *tracheiphilum* (Fot) was first detected in the NT on a commercial snake bean crop growing at Berrimah, Darwin in mid-1999. Fusarium wilt is a serious disease that causes considerable loss to the snake bean industry in Darwin. The industry was worth $1.1 million in 1999 when the disease was first discovered. By 2001 the wilt disease affected 75% of farms growing snake beans. Production is down to below 50 per cent. The initial investigations into the disease, together with early experiments, were reported in the 2000-2001 Technical Annual Report.

Method and Results:

Screening for resistance
Snake bean lines were obtained from Darwin, Biloela Queensland, Sunland Seeds NSW, Taiwan, the West Indies and the USA. In two major screenings in 2000 and 2001, 49 snake bean lines and several cowpea lines were screened for resistance to a 1999 isolate of Fot. It is planned to screen the remainder of the snake been lines in a third major screening. Five snake bean lines were identified with resistance to the 1999 isolate. However, none of these lines had the desirable culinary and horticultural characteristics so as to immediately replace the standard commercial variety, Green Pod Kaohsiung (GPK).

Races and VCG of Fot
World wide, four races of Fot are known that attack cowpeas or snake beans. All four of these races are present in the USA, with different States having different combinations of races. At present, the race or races of Fot that attack snake beans in Darwin are not known. The standard differential cowpea lines previously used to distinguish the races in the USA are no longer identifiable. We have imported a new set of cowpea race differential varieties from Dr. Jeff Ehlers of the University of California Riverside, USA through the Australian Tropical Crops Genetic Resource Centre. They should enable us to identify the race or races of Fot in Darwin. The seeds of these differential varieties will have to be multiplied to have sufficient amounts to use for testing the three isolates. Initial experiments in 2001-2002 with the vegetative compatibility group (VCG) technique showed promise of obtaining the correct mutants for performing the VCG test. We are hopeful of success with VCG in 2002-2003.

Breeding for resistance
Because no suitable cultivar was found in the screening tests, we commenced a back-crossing breeding program with advice from Dr. Ehlers in 2001 with the aim of incorporating resistance from a cowpea into the standard commercial snake bean line, GPK. The final variety from this program needs to have the desirable horticultural and culinary characteristics of the GPK snake bean, with strong stable resistance to all Fot found in commercial farms in Darwin. At present, the bc1F1 generation is being multiplied clonally to provide sufficient quantity of identical plants for screening to determine resistant plants for further breeding. The breeding and screening program was set back for several months because of delays due to staff involvement in a major tomato quarantine issue.

Grafting to control Fusarium wilt
Before a resistant variety is found or developed that can replace the current susceptible variety, many growers will not plant snake beans. A successful workshop was held with the Horticulture extension officer, the Asian vegetables communication officer and several interested growers to demonstrate how the GPK variety can be successfully grafted onto resistant cowpea and grown in Fusarium wilt infested soil. We hope this can be used as an interim measure until a satisfactory resistant variety is released. Agnote I61 titled “Grafting Snake Beans to Control Fusarium Wilt” was produced describing this work.

PROJECT:	**Testing of Banana Germplasm for Resistance to Fusarium Wilt Tropical Race 4**
Project Officers:	**A. Daly, G. Walduck, C. Kelly, B. Conde, S. Bellgard, L. Ulyatt and I. Arao-Arao**
Location:	Darwin

Objective:

To identify banana varieties with resistance/tolerance to tropical race 4 Fusarium wilt.

Background:

The detection of Tropical Race 4 of *Fusarium oxysporum* f.sp. *cubense* (*Foc*), a disease for which there is no means of effective chemical control, in several localities in Darwin's rural area since 1997 has highlighted the need to seek sources of resistance to the pathogen. A site at the Coastal Plains Horticultural Research Farm, gazetted as the Coastal Plains Banana Quarantine Station (CPBQS), has been built and artificially infected with the soil-borne disease. The response of a number of different banana varieties is being currently trialled.

Results:

Inoculation of the trial site with the Tropical Race 4 strain of *Foc* took place in November 2001. To date, 15 of a proposed 19 varieties have been planted at the site. The varieties being trialled were not inoculated directly. Plants of the highly susceptible variety known as *Pisang berangan* were interplanted with the varieties to be tested. These plants were inoculated with *Foc* inoculum (sorghum grain infected with the fungus) placed in three holes created around the pseudo-stem of each plant. The roots of the plants were damaged in the process to increase the chance of infection. In all, 638 *P. berangan* banana plants were inoculated. Included in the trial were a total of 30 *P. berangan* datum plants (Treatment 15) in six replications for assessment of their reaction to the disease.

Symptoms of Fusarium wilt began to show in the inoculated plants the following month. Ratings of the external symptoms of the disease, on a scale of 1 to 5, were then taken on a weekly basis. In the first rating after disease symptoms became apparent, out of 638 inoculated plants, 118 were showing symptoms in December. Three of the *P. berangan* datum plants were also showing symptoms of the disease. In March 2002, Fusarium wilt symptoms became apparent in many of the other varieties tested by which time most of the inoculated *P. berangan* plants were heavily infected or had already succumbed to the disease. External ratings were performed on each plant until either the disease symptoms reached stage 5 or a bunch was ready for harvest at which time the plant was cut down to verify the presence of the disease in the pseudo-stem. Some samples were selected for confirmation of the disease in the lab by isolations and VCG testing, a method that determines whether an unknown strain of *Foc* is from the same clonal line as a known strain of *Foc* i.e. Tropical Race 4 (Table 1).

Table 1. Varieties that showed symptoms of Fusarium wilt and subsequently tested positive for the Tropical Race 4 strain of the disease

Treatment No.	Rep. No. sampled	Rep. No. VCG tested	VCG reaction to Trop. Race 4 Strain
1	1-5	2	+
4	1-5	2	+
7	1-2	2	+
8	1-5	1	+
9	1-5	1	+
10	1-5	3	+
15	1-3,5	5	+

Tissue cultured plantlets of the remaining varieties to be tested have arrived and are currently being grown in pots until they are ready for planting in the trial site.

In addition to the varietal assessment at the CPBQS, a plot has been designated for testing a number of tissue cultured Cavendish banana plants treated with biological control agents shown to have anti-*Foc* properties *in vitro.* These agents included two types of bacteria and one type of mycorrhiza. The plants were first grown in pots in a shade house for a few months. With some plants set aside as untreated controls, one application of the mycorrhiza was made to some of the Cavendish plants at potting. The remaining plants received periodical drenches with one of the two types of bacteria during the time they were growing in the pots. In June 2002, these banana plants were planted in the trial site and inoculated with *Foc* by a similar method to that described earlier, although at a lower rate. The roots of the plants were not damaged during the inoculation process as with the previous *Foc* inoculations. The plants will be monitored over the coming months and their reaction to *Foc* assessed.

Twelve rows of Cavendish plants have also been planted at the back of the trial area. These were spare plants derived from tissue culture. The area in which they are growing was not deliberately inoculated with *Foc* using the sorghum grain inoculum as previously described. The area appears to have become infested with the disease by movement of contaminated machinery, and also movement of the disease from the adjacent inoculated row within the varietal assessment area. The plants within these rows are being monitored on a monthly basis to gain a greater understanding of the spread of *Foc* within a Cavendish monoculture and the factors involved.

A further aspect of research taking place at the CPBQS is a study of the persistence of *Foc* on weed species common in areas of banana cultivation and growing within the trial area. An honours student from the NTU, Chelsea Hennessey, is collaborating with the Plant Pathology section and Horticulture Division to conduct this research. The work involves routine isolations from the roots of the selected weed species. Any isolated cultures resembling *Foc* will undergo VCG and PCR testing to confirm their identity. Persistence of *Foc* at discrete points within the root vascular tissue of common weeds may contribute to a long survival period of the fungus in the soil after bananas have been removed.

Chelsea is also conducting a pot trial to test the reaction to *Foc* of three varieties of heliconia and one variety of ginger. This is taking place in a shade house constructed within the CPBQS. It is intended that these and other varieties of heliconia and ginger will be planted in the infected area of the trial site.

PROJECT: Banana Fusarium Wilt Surveys

Project Officers: **A. Daly, E. S. C. Smith, J. Swan, G. Walduck, S. Bellgard, B. Condé, L. Ulyatt and I. Arao-Arao**

Location: Darwin

Objective:

To survey for Fusarium Wilt (Panama Disease) in commercial banana plantations.

Background:

Following the initial detection of tropical race 4 of Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*) on a Northern Territory banana plantation in 1997, the disease subsequently became established on four other major banana producing properties. Two of these properties are no longer growing bananas. The two properties continuing to grow bananas have a number of sites of Fusarium wilt infection and the disease is being managed to allow banana production for as long as it is viable or until plants resistant to the disease can be offered as a replacement. To aid the management of the disease, surveys of these properties were conducted to determine the extent of the spread of the disease and locate individual sites of infection.

Method and Results:

In December 2001, staff visited a large commercial plantation at Lambell's Lagoon to conduct a preliminary survey for Fusarium wilt. Six new detections were made. Based on these findings it was decided to perform a comprehensive survey of the entire property to locate and mark infections, which had not been detected by management or workers on the property. To enable this to be done quickly and efficiently the services of staff from AQIS, NT Quarantine and the Horticulture Division were utilised. Following a group briefing on the external symptoms of the disease, the survey commenced and each row on the property was checked by one of the staff. When a suspect plant was observed one of the plant pathologists examined the internal tissue. A sample was taken if internal discolouration was evident. During the survey, 50 banana plants were sampled and taken back to the Plant Pathology Laboratory for analysis. Out of them, 49 of were positive for Fusarium wilt. Management staff of this property was advised of the locations of the diseased plants, which were subsequently destroyed. staff will continue to survey this property on a regular basis over the next 12 months to study the epidemiology of Fusarium wilt in this environment.

The second operating banana property with Fusarium wilt was surveyed in April 2002. Again the entire property was surveyed and involved Quarantine and Horticulture staff. All of the 18 banana plants sampled tested positive for Fusarium wilt. Management was advised of the findings.

PROJECT: Australian Cotton CRC

Project Officer: S. Bellgard (0.2 FTE in-kind contribution)

Location: Katherine Research Station

Objective:

To develop sustainable cotton farming systems.

Results:

In 2001-2002, the following research outcomes were achieved:

- Cultivar tolerance to tropical rust at KRS 2001.
- Variation in the incidence and severity of *Alternaria* leaf spot in relation to irrigation-type and cultivar at KRS 2001.
- Beneficial mycorrhizas associated with commercial cotton and native *Hibiscus* species growing in the monsoonal tropics of WA.
- Northern Cotton Disease Survey September 2001.

PROJECT: Survey for Banana Sigatoka

Project Officer: A. Daly

Location: Darwin

Objective:

To survey Sigatoka-like diseases in bananas and submit samples to Queensland Department of Primary Industries for detection of Black Sigatoka.

Background:

As part of the national surveys for Sigatoka, leaf samples showing Sigatoka symptoms were collected from commercial plantations and other sites and forwarded to QDPI Mareeba for identification of the pathogen. The survey aims to detect any black Sigatoka, which is not readily distinguishable from the common yellow Sigatoka in the field.

Method and Results:

Results of samples with leaf spot symptoms collected from two commercial properties in March 2001 and from a rural property at Howard Springs in July 2001 were received within a month of submission. All samples tested negative for black Sigatoka. Samples collected from a plantation near Gove with leaf spot symptoms were submitted in April 2001. However, the samples could not be processed at the time and deteriorated before an identification of the leaf spot could made. Inability to identify this sample and the long delay in results for samples collected last year were due to the need to process a large number of leaf samples from north Queensland during an outbreak of black Sigatoka in that area in April 2001. Subsequent 2001/2002 wet season collections in the NT were suspended to allow the QDPI laboratory at Mareeba to cope with the volume of samples being analysed during a black Sigatoka management program running at that time.

SUBPROGRAM: Entomology

PROJECT: Arthropod Identification and Control Service

Project Officers: **D. Chin, G.R. Brown, E. S. C. Smith, M. Connolly and H. Brown**

Location: Territory wide

Objective:

To provide accurate advice on the identification and control of agricultural, horticultural and domestic arthropods to primary producers, government personnel, pest control operators and the general public.

Background:

The Section provides an advisory service on entomological matters pertaining to agricultural, horticultural or domestic situations. Extension enquiries include phone calls on identification and advice on control of insects, grower visits, examination of specimens delivered to DBIRD offices; talks provided to industry organisations, schools and the university; and presentations at departmental field days, rural, horticultural and agricultural shows. The nature of the enquiry and the recommendations provided are recorded in a database. The recorded information may be used for future planning of research and allocation of resources.

Results:

During the year, the Section received 1450 enquiries. The proportion of the various client groups and the difference in comparison to the 2000/2001 period are shown in Table 1.

Table 1. Types and numbers of enquiries received in 2001/02

Enquiry status	2001-2002 Number	2001-2002 Percent %	2000-2001 Percent %	%Difference
Government	497	35	41	-6.0
Household	368	25	20	+5.0
Growers	317	22	24	-2.0
Other	240	17	13	+4.0
PCO	28	2	2	0
Total	**1450**	**100**	**100**	

The largest category of enquiries was from staff within the Government (NT and interstate). The majority of these enquiries were from other sections within DBIRD such as Horticulture, Quarantine and Plant Pathology. It also includes joint enquiries involving consultation or analyses between two or more Sections.

The main enquiries were for identification of specimens or providing recommendations on pest control. The slight decrease in the proportion of enquiries in the “Grower” category this year compared to last was due to the Section providing a larger number of recommendations or advice to growers through other departmental staff or other organisations such as the Northern Territory Horticultural Association. There was an increase in the proportion of enquiries received from householders that may be from previous publicity on Quarantine matters or specific exotic pest incursions. The increase in the “Others” category was predominantly due to a greater number of enquiries from school teachers, university students and lecturers, private agricultural consultants and private companies.

The promotion of integrated pest management through field demonstrations and displays at open days and rural shows has continued to generate interest amongst growers. In particular, there were three workshops provided on integrated pest management of mangoes which provided training for growers in identification and monitoring of pests and beneficials, and the use of cultural, biological and chemical control.

The section, in conjunction with Plant Pathology and Horticulture, also produced a field guide on the identification of pests, diseases, and disorders of mangoes.

Extension trends and enquiries of interest

Commercial crops

Mangoes and other tropical fruit

October-November 2001
In the late dry and build up, trees infested with longicorn borers sometimes exhibit signs of stress or even death. In the main, trees affected by stress such as from lightning, water logging, water stress or pruning were prone to attack. Longicorns generally attack trees in the wet or early dry season. Infested trees are usually undetected until symptoms are advanced which is usually in the late dry season or build-up. Orchards with longicorn damage were inspected in October. Trees attacked were those initially struck by lightning during the previous wet season. Symptoms seen on these trees were quite advanced and control was difficult or impossible.

Other problems of interest during this period included mealybugs in citrus, tarsonemid mites on guava, and ginger ant control in a commercial banana plantation.

December 2001
A commercial property of dragon fruit was inspected for ant damage to the stems and fruit. It was found that there were several species of ants involved. The two main ants that were chewing on the fruit and stems were *Solenopsis geminata* (Fabricius) (Hymenoptera: Formicidae) and *Iridomyrmex sanguineus* Forel (Hymenoptera: Formicidae). *Tapinoma* sp. (Hymenoptera: Formicidae) was found in the calyx lobes of the fruit. Other species found on the plants were *Opisthopsis* sp. (Hymenoptera: Formicidae) and a black *Iridomyrmex* species (Hymenoptera: Formicidae).

February –April 2002
A company growing bush tucker sent in numerous samples of insects from a plot of *Solanum centrale* from central Australia. Most of the specimens were either pollinators, predators or just resting on the plants. The only pests were a few caterpillars.

Information on methods to breed blowflies (Diptera: Calliphoridae) for pollinating mango flowers was requested from a commercial mango grower in Katherine.

Nests of the ant, *Polyrhachis delicata* (Crawley) (Hymenoptera: Formicidae) have become more common this season especially in the Howard Springs area. These ants build small nests from gluing leaves together with resin and have a habit of making a drumming noise when disturbed.

May-June 2002
Pheidole megacephala (Fabricius) (Hymenoptera: Formicidae) was recorded from a mango orchard in Acacia Hills. The ant was widespread and appeared to be excavating the bark of mango trees. Possible treatments were discussed.

Dragon fruit with scarring was submitted for identification. At first the damage appeared to be due to thrips or mites but was later determined to be caused by ants chewing the fruit.

Amblypelta lutescens lutescens (Distant) (Hemiptera: Coreidae) was recorded as a serious pest on pawpaws on a commercial property at Daly River.

Cucurbits and vegetables
Advice was provided to Asian vegetable growers on the identification and control of *Thrips palmi* Karny (Thysanoptera: Thripidae) on long melon, hairy melon, button squash and loofa. For other crops, advice was provided for the control of cucumber moth and pumpkin beetle on cucurbits and *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on sweet corn. Advice for control of aphids on chillies and eggplant was supplied to growers. Chemically resistant populations were suspected on both crops.

A species of marsh fly (Diptera: Ephydridae) was collected in tomato seedlings from a commercial grower. The larvae were boring into the stems of young seedlings and causing the stem to collapse.

Ornamentals and nursery plants
The majority of enquiries were on the identification and control of caterpillars and various pests on heliconias and palms. Nurseries requested advice on the control of thrips on Cycas revoluta.

Other crops
Cockchafers (Coleoptera: Scarabaeidae) were a significant problem in plot of pangola pasture. About 20-30% of the 50 ha crop was infested. Control was not possible due to the difficulty of penetrating the thick mulch and the cost of spraying.

Household and backyard enquiries
The most common enquiries received by the Section were on the identification of ants and spiders. There was a general concern from the public regarding the fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae) and anything that was similar in appearance was collected and provided to the Section for identification. No fire ants were detected from the samples submitted. Ant species often mistaken for fire ants by the public included *Solenopsis geminata* (Fabricius) (ginger ant), *Polyrachis*, *Odontomachus* sp., *Iridomyrmex sanguineus* Forel, I*ridomyrmex* sp. and *Cerapachys* sp. (Hymenoptera: Formicidae). Other common ant problems included the coastal brown ant, *Pheidole megacephala* (Fabricius) (Hymenoptera: Formicidae) in the northern suburbs and Singapore ant *Monomorium destructor* (Jerdon) in Darwin suburbs.

Spider enquiries are generally common in the build up and wet season. Mouse spider (*Missulena pruinosa* Levitt-Gregg) (Araneida: Actinopodidae) enquiries commenced in August with sightings of the male and continued throughout the wet season. Females were recorded in the late wet and early dry season, particularly in May and June. The golden orbweaver spiders, *Nephila* spp. (Araneida: Tetragnathidae) has become quite common in established backyards and are usually unwelcome due to their large and “scary” appearance. Other spiders commonly encountered in households and backyards requiring identification were huntsman spiders (Araneida: Heteropodidae), barychelids (Araneida: Barychelidae), brown widows (*Latrodectus geometricus* C.L. Koch) (Araneida: Theridiidae), redbacks (*Latrodectus hasselti* Thorell) (Araneida: Theridiidae) and even a large plastic species in a sandpit (spotted by a teacher who would not approach it, but requested Entomology staff to come and remove “this very large, potentially dangerous and unusual species”).

Other enquiries of interest included information on the following:

- Bush bees, *Trigona* (Hymenoptera: Apidae). (February)
- Bag shelter moth larvae on *Planchonia careya*, and other itchy caterpillars that cause allergic skin reactions. (February)
- Large numbers of *Amblypelta lutescens lutescens* Distant (Hemiptera: Coreidae) were seen causing significant damage to backyard pawpaws in Palmerston. (March)

Other public enquiries
Advice on the control of the redback spider (*Latrodectus hasselti* Thorell) (Araneida: Theridiidae) was supplied to a contractor to treat a series of demountables transported from WA.(October)

Control of earthworms was requested on two occasions, one in the lawn of a home garden and the other on a golf course. In both situations the worms were tunnelling into the soil and depositing numerous small mounds of soil on the lawn. (October-November)

Information was provided to a resort in Broome on palm leaf beetle control and discussions on the introduced wasp parasitoid, *Tetrastichus brontispae* (Ferriere) (Hymenoptera: Eulophidae). (December-January)

Various food products infested with insects including moths from packets of cereal and chocolates. The Indian meal worm, *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae) was reared from a packet of beef jerky. (February)

Silphid beetle larvae (Coleoptera: Silphidae) were collected from the carcass of a camel. (February)

Information on control of *Achaea janata* Linnaeus (Lepidoptera: Noctuidae) was supplied for the treatment of a high infestation on crotons (*Codiaeum* sp.) at a Darwin bowls club. On a separate occasion in Katherine, hundreds of *A. janata* caterpillars were congregating on the high-level railway bridge for several days, annoying construction workers. (March- April)

A large assassin bug (family Redviidae) was submitted from a man in Alice Springs. The bug was found inside his jeans where it had attacked his leg. (April)

An unusual large black tadpole from a fishpond in a Darwin suburb was given to the section for identification as the enquirer was concerned about it being a cane toad. The NT Museum identified the tadpole as the marble frog *Limnodynastes convexiusculus*. (May)

An establishing comb of feral European honey bees, *Apis mellifera* Linnaeus (Hymenoptera: Apidae) was relocated from an aged-care facility in Katherine East to a new location. (October)

Thrips were found in large numbers on plants at a wildlife park in Alice Springs. These included *Thrips tabaci* Lindemann (Thysanoptera: Thripidae) on *Eremophila christopheri* and *Eremophila maculata*; and *Gynaikothrips* sp (Thysanoptera: Phlaeothripidae) on *Ficus brachyopoda.* (May)

PROJECT: Northern Territory Economic Insect Reference Collection

Project Officers: **H. Brown, H. Wallace, L. Zhang, G. R. Brown, M. Connolly and E. S. C. Smith**

Location: Berrimah Farm

Objective:

To develop, curate and maintain a reference collection of economically important arthropods of the various NT agricultural and horticultural industries and to develop and maintain a suitable, retrievable database of all specimens held in the collection.

Background:

The insect reference collection was initiated in 1970 and rapidly became the main insect reference collection in the NT. Over the years, the collection expanded to include economically important arthropods from agricultural, horticultural and domestic situations as well as general collections. In 1992, the majority of the non-economic insect specimens were donated and transferred to the NT Museum.

Results:

A total of 4,100 specimens were added to the database during the year.

Addition of museum specimens onto the ACCESS network database is continuing. At the beginning of May a full time technician was employed for a three-month period to put on the database information on the remaining insects not already recorded. To date, over 30,990 specimens have been entered on the database, constituting about 98% of the entire collection.

The number of specimens in the collection is ever increasing and there is now a catalogued sub-collection maintained at Katherine Research Station. This collection has 1475 specimens of which 351 have been recorded on the main database and 147 are still to be entered. The regional collection retains only representative specimens of the more common insects as storage conditions are not ideal and all specimens of interest will be kept in the main Darwin collection.

A new dehumidifying air-conditioning unit was installed in the museum this year. This should reduce the amount of fungal and mould growth on specimens, thus reducing the workload for cleaning specimens.

During 2001/2002 the Branch forwarded 83 specimens to specialist taxonomists for species confirmation or identification. Most specimens were of economic significance.

New records
The following were new records determined during 2001/2002. These are indicated as a new regional or country locality (New NT, New Australia) or new host records for the NT (New host).

ACARINA

Eriophyidae

Aceria pongamiae Keifer (New Australia)
forming galls on leaves of *Pongamia pinnata* at Marrara (New Australia)

Diptilomiopidae

Diptilomiopus assamica Keifer
on leaves of *Citrus paradisi* at Berry Springs (New NT)

Hemisarcoptidae

?Hemisarcoptes sp.
dense population feeding on oriental scale (*Aspidiotus destructor* Signoret) (ex fruit of *Carica papaya*). (New NT)

Tenuipalpidae

Brevipalpus ? californicus (Banks)
ex. leaves of *Brunfelsia densifolia.* (New NT)
Brevipalpus californicus (Banks)
on leaves of weed, *Clitoria termalea.* (New host)
on *Vigna unguiculata.* (New host)
Brevipalpus phoenicis (Geijskes), *Brevipalpus californicus* (Banks)
on fruit of *Psidium* sp. (New host)
on fruit of *Citrus paradisi*. (New host)
on *Vigna unguiculata.* (New host)

Tetranychidae

Eutetranychus sp.
on *Trema tomentosa.* (New NT)
Eutetranychus orientalis (Klein)
on *Manihot esculenta*. (New host)
?*Eotetranychus* sp.
on weed, *Carthamanus major.* (New NT)
Oligonychus punicae (Hirst) or *O. manigiferus* (Rahman)
on *Melaleuca* sp. (New host)
Tetranychus lombardinii Baker and Pritchard
feeding on leaves of *Vigna unguiculata* (snake bean) (New NT)
Schizotetranychus ?andropogoni (Hirst)
on grass, *Paspalum notatum*. (New NT)

Stigmaeidae

Agistermus sp.
on *Trema tomentosa.* (New NT)

HEMIPTERA

Aleyrodidae

Aleurocanthus spiniferus (Quaintance)
on *Maranthes corymbosa.* (New host)
Bemisia afer (Priesner and Hosny)
on *Aneranthros* sp. (New NT)
Bemisia tabaci (Gennadius)
on *Euphoribia milii.* (New host)
Dialeurodes kirkaldyi (Kotinsky)
on *Jasminum* sp. (New host)
on *Jasminum sambuca.*(New host)
Dialeuropora decempunctata (Quaintance and Baker)
on *Acacia mangium.* (New NT)
Nigrasialeyrodes n. sp.
(T269) on *Acacia* sp. (New NT)

Aphididae

Aphis gossypii Glover
on *Polianthes tuberosa.* (New host)
Aphis nerii Boyer de Fonscolombe
on rubber bush. (New NT)
Hysteroneura setariae (Thomas)
on gamba grass. (New host)
on *Bambusa arnhemica.* (New host)
Myzus persicae (Sulzer)
leaves of *Ipomoea aquatica* (kangkong (New NT)
Rhopalosiphum maidis (Fitch)
on *Pennisetum glaucum.* (New host)

Asterolecaniidae

Bambusaspis nr *bambusae* (Boisduval)
on *Bambusa arnhemica.* (New NT)

Coccidae

Ceroplastes rubens Maskell
on ?Gardenia. (New host)
on *Murraya paniculata.* (New host)
Coccus hesperidum Linnaeus
on *Thevetia peruviana.* (New host)
on *Monsteria* sp. (New host)
on *Tinospora smilacina.* (New host)
?*Coccus hesperidum* Linnaeus
on *Murraya paniculata.* (New host)
on *Lagerstroemia speciosa.* (New host)
Coccus longulus (Douglas)
on *Acacia holosericea.* (New host)
Eucalymnatus tessellatus (Signoret)
on *Chrysophyllum cainito.* (New host)
Parasaissetia nigra (Nietner)
on *Ficus benjamina.* (New host)
Pulvinaria psidii Maskell
on *Garcinia livingstonei.* (New host)
on *Chrysophyllum cainito.* (New host)
on fruits of *Nephelium lappaceum* (New host)
Pulvinaria urbicola Cockerell
on *Duranta* sp. (New host)
on *Garcinia livingstonei*. (New host)
? Pulvinaria urbicola Cockerell
on *Gmelina arborea*. (New host)
Saissetia sp.
on *Terminalia catappa*. (New host)
on *Terminalia ferdinandiana*. (New host)
Saissetia coffeae (Walker)
on *Hibiscus* sp. (New host)
on fruits of *Nephelium lappaceum* (New host)
on *Plumeria* sp. (New host)
? *Saissetia coffeae* (Walker)
on *Hibiscus* sp. (New host)

Diaspididae

Aonidiella aurantii (Maskell)
on *Cycas revoluta*. (New host)
Aonidiella comperei McKenzie
on mango. (New NT)
on *Thevetia peruviana*. (New NT)
Aonidiella inornata McKenzie
on *cycas*. (New NT)
Mangifera indica. (New host)
on *Cycad thouarsii*. (New host)
on *Terminalia ?erythrocarpa*. (New host)
?Aonidiella orientalis (Newstead)
on *Plumeria rubra*. (New host)
Aspidiotus sp.
on *Episcia* sp. (New host)
Chrysomphalus aonidum (Linnaeus)
on *Duranta* sp. (New host)
on *Mangifera indica*. (New host)
on potted *Musa paradisiaca*. (New host)

Chrysomphalus dictyospermi (Morgan)
on *Diospyros ?digyna*. (New NT)
Furcaspis biformis (Cockerell)
on *Phoenix roebellinii*. (New host)
Furcsapis ?biformis (Cockerell)
on orchid. (New NT)
Hemiberlesia lantaniae (Signoret)
on *Dimocartus longana*. (New NT)
Lepidosaphes gloverii (Packard)
on *Plumeria rubra*. (New host)
Lepidosaphes ?gloverii (Packard)
on palm leaves. (New host)
Lepidosaphes sp.
on *Terminalia ferdinandiana*. (New host)
on *Musa paradisiaca*. (New host)
Parlatoria proteus (Curtis)
on *Ophiopogon japonicus*. (New host)
Pinnaspis strachani (Cooley)
on *Terminalia catappa*. (New host)
on *Musa paradisiaca*. (New host)
on *Cycas thouarsii*. (New NT)
on *Plumeria rubra*. (New host)
on *Centipeda* sp. (New host)
on *Capsicum anuum*. (New host)
on *Passiflora foetida*. (New host)
on *Mangifera indica*. (New host)
?Pseudaonidia trilobitiformis (Green)
on *Nerium oliander*. (New NT)
on *Grevillea* sp. (New NT)
Unaspis citri (Comstock)
on *Citrus maxima*. (New host)
on *Calopyllum inophyllum*. (New host)

Pseudococcidae

Planococcus citri (Risso)
on *Artocarpus heterophyllus*. (New host)
on *Tinospora smilacina*. (New host)
Dysmicoccus nr*. laporteae* Williams
on *Acacia holosericea*. (New NT)
Ferrisia virgata (Cockerell)
on *Acalapha* sp. (New host)

LEPIDOPTERA

Pyralidae

Prays nephelomima Meyrick
Citrus paradisi (New NT)
Conogethes nr. *pluto* (Butler)
reared from stem and flower of Alpinia purpurata (New NT)

Tineidae

Opogona nr. *glycyphaga* Meyrick
reared from flower of *Alpinia purpurata* (ornamental ginger) (New host)

THYSANOPTERA

Phlaeothripidae

Dolichothrips sp.
ex. *Hibiscus tiliaceus* (New NT)
Haplothrips bituberculatus Girault
ex. deformed and stunted leaves of *Dolicandrone* sp. (New host)

Thripidae

Astrothrips ?aureolus Stannard and Mitri
damaging leaves of *Hymenocallis* sp. (Liliaceae) (New NT)
Australothrips ?bicolor Bagnall
causing heavy damage to *Terminalia ferdinandiana* (New host)
Caliothrips striatopterus (Kobus)
ex. (milk thistle) *Sonchus oleraceus* (New NT)
?Megalurothrips typicus Bagnall
in large numbers on new flush leaves of *Mangifera indica* (New host)
Megalurothrips ?typicus Bagnall
ex. *Vigna radiata* flowers (New NT)
Megalurothrips usitatus (Bagnall)
ex. *Sesamum indicum* flowers (New NT)
ex. *Vigna radiata* flowers (New NT)
Scirtothrips dorsalis Hood
ex. Cocoa leaves (New host)
?Teuchothrips sp.
ex. *Eremophila* sp. (New NT)
?Thrips orientalis Bagnall
ex. potato vine (New NT)
Thrips parvispinus Karny
ex. *Jasminium sambuca* (New NT)

PROJECT: Quarantine Entomology

Project Officer: G. R. Brown

Location: Darwin

Objectives:

To identify insects and other organisms intercepted by quarantine officers.

To provide advice on the quarantine significance of these organisms and to put the records on a database.

Background:

AQIS provides partial funding for the Quarantine Entomologist to provide identifications on insects intercepted by quarantine officers in the Northern Territory.

Methods:

Insect and other animal samples collected by Quarantine inspectors are submitted with insect interception record sheets to Quarantine Entomology for identification and advice. Advice is provided and the insect interception identification record sheets are completed. Copies of both sheets are forwarded to the relevant inspectors, and to AQIS, Canberra for recording on the database.

Interceptions considered to be of quarantine significance were investigated further.

Results:

During the year, 429 insect interceptions totalling 529 samples were received. Most were collected at Perkins Wharf (149), Darwin Airport (167), Darwin Harbour anchorages (90), various Darwin Harbour wharves and marinas (67) and at the Quarantine Inspection Depot (11). The rest were collected from seven sites, including Rooney's Shipping (8) and RAAF Darwin (6) and RAAF Tindal (2). However, 28 were listed as miscellaneous, which included ship galleys and on-board insectacutors.

This compares with 296 insect interceptions totalling 350 samples in 2000/01. Only eight were collected from Rooney's Shipping this year, compared with 30 last year.

Species found:

The following is a list of taxa and the number of samples examined:

Acarina..1
Amphibia..1
Aranaea 61
Blattodea..11
Coleoptera 164
Collembola...3
Dermaptera..8
Diplopoda...1
Diptera 56
Mantodea...1
Mollusca...9
Hemiptera 20
Hymenoptera 98
Isopoda 2
Isoptera..4
Lepidoptera.....................................33
Orthoptera..9
Passeriformes eggs...........................1
Pseudoscorpiones 5
Psocoptera.......................................25
Squamata 6
Thysanoptera.....................................1
Thysanura..4
Unknown eggs...................................5

Most of the above sample numbers are higher than those collected last year. However, spiders (Aranaea), Hymenoptera (ants, bees and wasps, but especially ants) and Lepidoptera (moths and butterflies, but especially moths) were significantly higher this year. There were 61 Aranaea compared with 19 last year, 98 Hymenoptera compared with 34 last year, and 33 Lepidoptera compared with 18 last year.

Countries of origin:

The following is the number of samples examined. Some countries are grouped regionally because there were few interceptions from them.

Africa..3
Australasia/Oceania 13
Bangladesh..8
Brunei 9
China 12
East Timor 190
Europe 16
India 10
Indonesia 125
Malaysia...24
Other Asian countries.......................20
Singapore 27

In addition, 58 were collected on ships; the origin of another 14 was unknown.

Seasonal occurrence

Figure 1 shows the numbers of different specimens collected each month. Over 20 were collected in each month, with the least collected in June, July and September. About 40 were collected in most other months. The highest numbers of specimens were collected in April (85), and January (60).

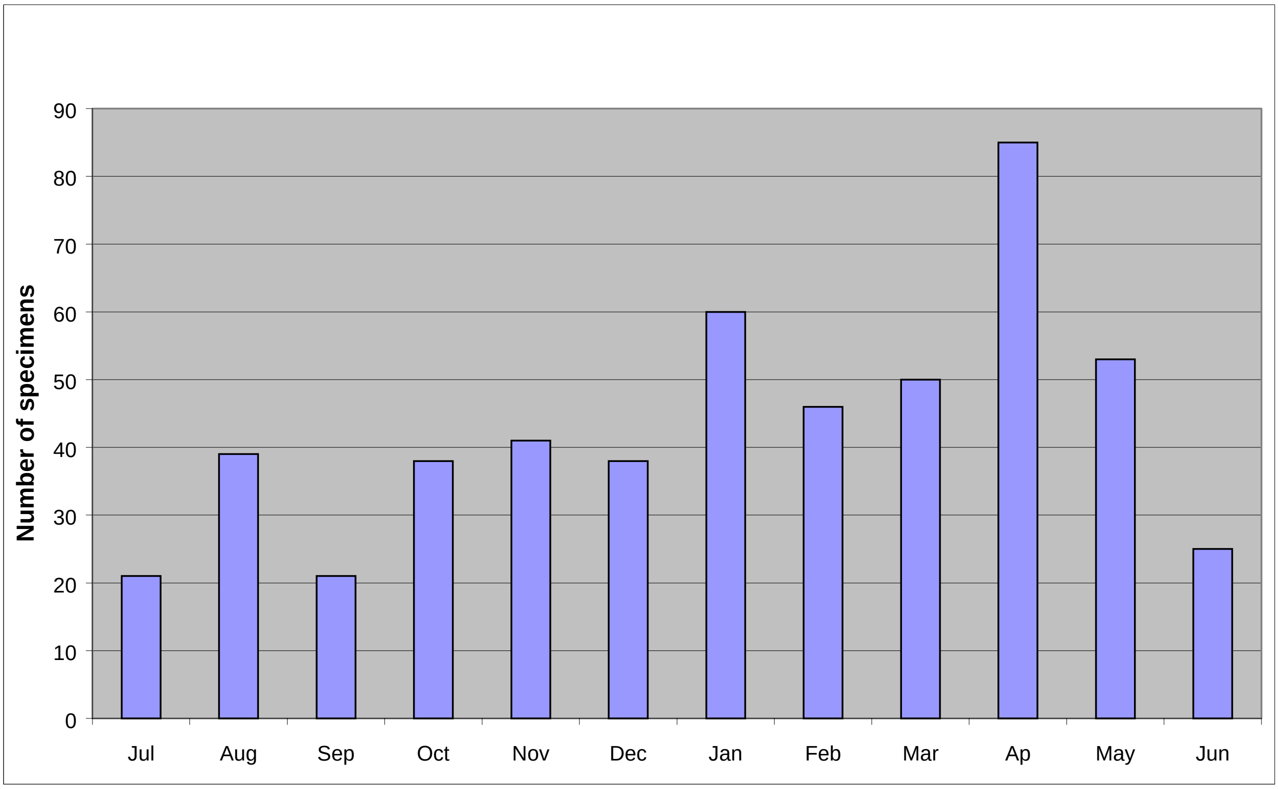


Figure 1. Number of specimens collected over the year

Interesting records
The majority of specimens received were either stored product pests, borers, or ants. Records of interest included:

Five records of harlequin cockroach, *Neostylopyga rhombifolia* (Blattodea: Blattidae)

Two records of drywood termites, *Cryptotermes* spp. (Isoptera: Kalotermitidae)

Eleven records of exotic mosquitoes: eight *Aedes aegypti* (Linnaeus) and one *Aedes albopictus* (Skuse), and two *Aedes scutellaris* complex (Diptera: Culicidae)

Two records of trogoderma larvae, *Trogoderma variabile* Ballion and *Trogoderma* sp. (Coleoptera: Dermestidae)

One record of adult cerambycid beetle, *Rhaphuma annularis* (Coleoptera: Cerambycidae)

One record of a dead wasp, *Sirex* sp. (Hymenoptera: Siricidae)

Eighty five records of ants (Hymenoptera: Formicidae) including crazy ant, *Anoplolepis gracilipes* (five) and *Solenopsis geminata* (six)

One record of a dead giant honey bee, *Apis dorsata* Fabricius (Hymenoptera: Apidae)

One record of live juvenile bird-eating spiders, *Aphonopelma* sp. (Araneae: Theraphosidae)

Sixty records of spiders including 15 records of brown widow spider, *Latrodectus geometricus* Koch and six other theridiids (Araneida: Theridiidae), and 11 daddy-long legs spiders (Araneida: Pholcidae)

Four records of giant African snail, *Achatina fulica* (Bowdich) (Eupulmonata: Achatinidae) as well as five records of other exotic molluscs.

Five records of geckos (Squamata: Gekkonidae)

One record of a colubrid snake (Squammata: Colubridae)

PROJECT: Taxonomy of Scale Insects and Mealybugs (Hemiptera: Coccoidea) with Additional Records of Aphids (Hemiptera: Aphididae) and White Flies (Hemiptera: Aleyrodidae)

Project Officers: **G. R. Brown and L. Zhang**

Location: Territory wide

Objective:

To reliably identify scale insects and mealybugs and to recognise new occurrences particularly those of agricultural importance.

Background:

Many scale insects, mealybugs (Hemiptera: Coccoidea) and white flies (Hemiptera: Aleyrodidae) are serious agricultural pests. Over 800 species of coccoids placed in 13 families as well as 31 species of white fly are recorded from Australia. It is unknown how many of these occur in the Northern Territory, or the range of hosts they attack here. An overview was given in the 1999/2000 and 2000/2001 Technical Annual Reports.

Results:

A list of species identified (after mounting on slides) is given below, together with host and collection localities. Numbers prefixed by the letter “C” indicate quarantine interception numbers, the letter “T” for the taxonomy catalogue and “K” for Katherine. Other numbers refer to the database of the Entomology Branch.

Of note is the detection of *Lepidosaphes beckii* (Newstead) (Hemiptera: Diaspididae.) on citrus at Berrimah

The material examined and identified was as follows:

HEMIPTERA

Asterolecaniidae (Pit Scales)

Bambusaspis nr *bambusae* (Boisduval) (New NT)
(T156) on *Bambusa arnhemica* at Fannie Bay
Bambusaspis sp.
(T157) on *Bambusa arnhemica* at Fannie Bay
(T218, T219) on *Bambusa arnhemica* at Mary River

Coccidae (Soft Scales)

Ceroplastes rubens Maskell
(T139) on *Gardenia hygrophila* at the quarantine glass house, BARC, Berrimah (New host)
(T213B) on *Murraya paniculata* at East Arm Wharf (New host)

Coccus hesperidum Lindinger
(T153) on *Monsteria* sp. at Stokes Hill Wharf (New host)
(T185) on *Tinospora smilacina* at Berrimah (New host)
(T192) on *Thevetia peruviana* at Katherine Research Station (New host)

?*Coccus hesperidum* Lindinger
(T133) on *Lagerstroemia speciosa* at Marrara (New host)
(T179) on *Coffea* sp. at East Timor
(T213A) on *Murraya paniculata* at East Arm Wharf (New host)

Coccus longulus (Douglas)
(T257) on *Acacia holosericea* at Stokes Hill Wharf (New host)

Eucalymnatus tessellatus (Signoret)
(T197C) on *Chrysophyllum cainito* at Berrimah Research Farm (New host)

Milviscutulus mangiferae (Green)
(T178) on *Artocarpus heterophyllus* at East Timor

Parasaissetia nigra (Nietner)
(T147) on *Ficus benjamina* at Marrara (New host)

Pulvinaria psidii Maskell
(T197A & T197B) on *Chrysophyllum cainito* at Berrimah Research Farm (New host)
(T198) on *Garcinia livingstonei* at Berrimah Research Farm (New host)
(T251) on fruits of *Nephelium lappaceum* at Humpty Doo (New host)

Pulvinaria urbicola Cockerell
(T150) on *Duranta* sp. at Berrimah (New host)
(T170) on ornamental tree at Virginia
(T199) on *Garcinia livingstonei* at Berrimah (New host)

? *Pulvinaria urbicola* Cockerell
(T214) on *Gmelina arborea* at RAAF, Golf Course (New host)

Saissetia coffeae (Walker)
(T152) on *Hibiscus* sp. at Marrara (New host)
(T252) on fruits of *Nephelium lappaceum* (New host)
(T279) on *Plumeria* sp. at Palmerston (New host)

? *Saissetia coffeae* (Walker)
(T248) on *Hibiscus* sp. at Malak (New host)

Saissetia sp.
(T165) on *Terminalia catappa* at Katherine
(T223) on *Terminalia ferdinandiana* at Wildman River

Unknown
(T52) on *Melaleuca* sp. at Rapid Creek

Diaspididae (Armoured Scales)

Aonidiella aurantii (Maskell)
(T89A) on *Citrus* sp. at Nakara
(T142) on *Citrus maxima* at Katherine Research Station
(T146) on *Cycas revoluta* at Ironstone Lagoon Nursery, Berrimah (New host)
(T167) on *Cycas* sp. at RAAF, Tindal

Aonidiella comperei McKenzie (New NT)
(T186) on mango at the quarantine shade house, BARC, Berrimah
(T191) on *Thevetia peruvianas* at KRS, Katherine

Aonidiella inornata Mckenzie
(T207) on *cycad* at Palmerston
(T210) on *Mangifera indica* at Berrimah (New host)
(T216) on *Cycad thouarsii* at Palmerston (New host)
(T268) on *Terminalia ?erythrocarpa* at Marrara (New host)

Aonidiella orientalis (Newstead)
(T281) on *Carica papaya* at Mt Bundey, Camp Krusty

?Aonidiella orientalis (Newstead)
(T272) on *Plumeria rubra* at Berrimah (New host)

Aspidiotus destructor Signoret
(T241) on *Calopyllum inophyllum* at Fort Hill Wharf

Aspidiotus sp.
(T236) on *Episcia* sp. at Anula (New host)

Aulacaspis tubercularis Newstead
(T228) on *Mangifera indica* at Tiwi

Aulacaspis ? tubercularis Newstead
(T231) on *Mangifera indica* at 25km SE Katherine

Chrysomphalus aonidum (Linnaeus)
(T89C) on *Citrus* sp. at Nakara
(T163) on *Duranta* sp. at Boulter Rd, Berrimah (New host)
(T202) on *Mangifera indica* at Berrimah (New host)
(T226) on *Musa paradisiaca* at Arnhem Land
(T233) on potted *Musa paradisiaca* at Berrimah (New host)
(T263) on *Citrus* sp. at Berrimah
(T283) on *Rubiaceae sp.* at Mt Bundey, Camp Krusty

Chrysomphalus dictyospermi (Morgan) (New NT)
(T235) on *Diospyros ?digyna* at Berrimah

nr*. Fiorinia* sp
(T205B) on *Acacia* sp. at Shady Glen Caravan Park

Furcaspis biformis (Cockerell) (New NT)
(T174) on *Phoenix roebellinii* at Katherine (New host)

Furcsapis ?biformis (Cockerell)
(T175) on orchid at Darwin Botanic Gardens

Genaparlatoria pseugaspidiotus (Lindinger)
(39525) on *Vanda orchids* at Alawa

Hemiberlesia lantaniae (Signoret) (New NT)
(T196) on *Dimocartus longana* at Berrimah Research Farm
(T209) on *Thevetia peruviana* at Katherine Research Station

Lepidosaphes beckii (Newstead)
(T265) on *Citrus* sp. at Berrimah

Lepidosaphes gloveri (Packard)
(T90) on *Alstonia actinophylla* at Berrimah
(T234B) on *Citrus* sp. at Parap
(T240) on *Plumeria rubra* at Frances Bay (New host)
(T264) on *Citrus* sp. at Berrimah

Lepidosaphes ?gloverii (Packerd)
(T237) on palm leaves at Douglas Daly Park (New host)

Lepidosaphes sp.
(T89B) on *Citrus* sp. at Nakara
(T222) on *Terminalia ferdinandiana* at Wildman River (New host)
(T227) on *Musa paradisiaca* at Millingimbi, Arnhem Land (New host)
(T242) on *Alstonia scholaris* at Coonawarra

Parlatoria proteus (Curtis)
(T169) on *Ophiopogon japonicus* at Government House, Darwin (New host)

Parlatoria ziziphi (Lucas)
(T195) on *Citrus aurantifolia* at Dili, East Timor

Pinnaspis strachani (Cooley)
(T164) on *Terminalia catappa* at RAAF, Tindal (New host)
(T208) on cycad at Palmerston
(T217) on *Cycad thouarsii* at Palmerston (New host)
(T230) on *Plumeria rubra* at Katherine (New host)
(T247) on *Hibiscus* sp. at Fisherman’s Wharf
(T267) on *Terminalia catappa* at Marrara
(T278) on *Centipeda* sp. at Berrimah (New host)
(T280) on *Capsicum anuum* at Tiwi (New host)
(T286) on *Passiflora foetida* at Alawa (New host)
(T288) on *Mangifera indica* at Katherine (New host)

? *Pseudaonidia trilobitiformis* (Green) (New NT)
(T87) on *Nerium oliander* at Tiwi
(T92) on *Grevillea* sp. at Tiwi

Pseudaulacaspis cockerelli (Cooley)
(XA) on palm at Berrimah Research Farm

Unaspis citri (Comstock)
(T127) on *Citrus maxima* at Pine Creek (New host)
(T143) on *Citrus* sp. at Katherine
(T234A) on *Citrus* sp. at Parap

Unknown
(T74) on *Ophiopogon nigrescens* at Holmes Jungle
(T91) on *Petalostigma pubescens* at Holmes Jungle
(T94) on *Acacia* sp. at Tiwi
(T95) on *Melaleuca* sp. at Nakara

(T97B) on *Petalostigma pubescens* at Holmes Jungle
(T128 & T129) on *Citrus maxima* at East Timor
(T132) on *Pelalostigma pubescens* at Boulter Rd, Berrimah
(T135) on *Acacia* sp. at North Lakes
(T154) on *Morinda citrifolia* at Stokes Hill Wharf
(T176 & T244) on lichi, *Litchi chinesis* at Moil
(T215) on *Lophostemon* sp. at Marrara
(T289) on *Murraya paniculata* at The Narrows

Eriococcidae

Unknown
(T140) on *Eucalyptus phoenicea* at Katherine

Margarodidae (Fluted Scales)

Icerya aegyptiaca (Douglas)
(T183) on unknown weed at Alawa

Icerya sp.
(T177) on ornamental succulent at Dili, East Timor
(unnumbered) on *Casuarina* sp. at Alawa

Pseudococcidae (Mealybugs)

Dysmicoccus brevipes (Cockerell)
(T69) on *Arachis hypogaea* at Early Storm, Douglas Daly

Dysmicoccus nr. *laporteae* Williams (New NT)
(T224) on *Acacia holosericea* at King River Crossing, Katherine

?*Epicoccus* sp.
(T249) on *Mussaenda* sp. at Frances Bay

Ferrisia virgata (Cockerell)
(T151) on *Acalypha* sp. at Berrimah (New host)

Maconellicoccus hirsutus (Green)
(T162) on *Nephelium lappaceum* at Berrimah

Melanococcus phylodii Williams
(T159) on *Acacia* sp. at Darwin Airport

Planococcus citri (Risso)
(T184) on *Tinospora smilacina* at Berrimah (New host)
(T200) on *Artocarpus heterophyllus* at Berrimah Research Farm (New host)

Pseudococcus nr. *dendrobiorum* Williams
(T221) on *Terminalia ferdinandiana* at Wildman River

Pseudococcus sp.
(T203) on *Mangifera indica* at Berrimah

Unknown
(T194) on *Eucalyptus tetradonta* at Katherine

Aleyrodidae (White flies)

Aleurocanthus spiniferus (Quaintance)
(ET84) on unrecorded host from the Darwin area
(T158) on *Maranthes corymbosa* at Darwin airport grounds (New host)
(T204) on *Hibiscus* sp. at Darwin

Bemisia afer (Priesner and Hosny) (New NT)
(T168) on *Aneranthros* sp. at RAAF, Tindal

Bemisia tabaci (Gennadius)
(T187 &T190) on *Euphoribia milii* at the Horticulture shadehouse, BARC, Berrimah (New host)
(unnumbered) on unknown hosts at Alice Springs
(unnumbered) on taro, *Colocasia esculenta* from unknown locality
(unnumbered) on *Colocasia esculenta* at Humpty Doo

Dialeuropora decempunctata (Quaintance and Baker)
(unnumbered) on *Acacia mangium* from Melville Island. (New NT)

Dialeurodes kirkaldy (Kotinsky)
(T161) on jasmine at Tiwi (New host)
(T255) on *Jasminum sambuca* at Berrimah (New host)

Nigrasialeyrodes n. sp.
(T269) on *Acacia* sp. at Tiwi Barge

Aphididae (Aphids)

Aphis craccivora Koch
(T206) on cowpea at Berrimah

Aphis gossypii Glover
(T181) on *Catharanthus roseus* at Hera village, East Timor
(T189) on *Cucumis melo* at Lambells Lagoon
(A3) on *Polianthes tuberosa* at Humpty Doo (New host)
(T101) on *Citrus reticulata* at Katherine
(T102) on cotton, *Gossypium hirsutum*. at Katherine

Aphis nerii Boyer de Fonscolombe (New NT)
(T193) on rubber bush at Katherine

Astegopteryx nipae (van der Goot)
(C1469B) on *Areca catechu* at Quarantine Interception, Darwin Airport

Hysteroneura setariae (Thomas)
(T160) on gamba grass at Darwin Airport (New host)
(T220) on *Bambusa arnhemica* at Adelaide River (New host)

Rhopalosiphum maidis (Fitch)
(T266) on *Pennisetum glaucum* at Katherine Research Station (New host)

Unknown
(T181) on *Catharanthus roseus* at East Timor

PROJECT: Taxonomy of Mites (Acarina)

Project Officers: **L. Zhang and G. R. Brown**

Location: Territory wide

Objective:

To identify mites and prepare mite samples ready for confirmation by specialists or further identification, and to recognise new occurrences particularly those of agricultural importance.

Background:

Mites are important agricultural pests. Over 2,700 species of mite placed in 240 families are recorded from Australia. It is unknown how many of these occur in the Northern Territory, or which species are potential pests.

Method:

After clearing in Nesbitt's fluid, mite samples were mounted on slides with mounting medium (Hoyer's or Heinze – PVA). Identifications were conducted through the use of these slide-mounted specimens and appropriate keys to genera and species. All species which were new or new to Australia were determined by a mite taxonomy specialist.

Results:

A list of species identified during the year is provided below, together with host and collection locations. Numbers given "M" are for mite taxonomy catalogue.

ACARINA

Acaridae

Tyrophagus ?putrescentiae (Schrank)
(M98) dense population found in seed cool room at Katherine Research Station

Bdellidae

Unknown
(M83) on fruit of *Psidium* sp. at Berrimah
(M104) feeding on spider mites (M103) on *Mangifera indica* at Berrimah

Cunxidae

Unknown
(M104) feeding on spider mites (M103) on *Mangifera indica* at Berrimah

Diptilomiopidae

Diptilomiopus assamica Keifer (Confirmed by D. Knihinicki)
(M37) on leaves of *Citrus paradisi* at Berry Springs

Diptilomiopus sp. (Possibly new species) (Confirmed by D. Knihinicki)
(M42) on leaves of *Petalostigma pubescens* at Berrimah

Eriophyidae

Aceria hibisci (Nalepa) (Identified by D. Knihinicki)
(M49) found in galls on leaves of *Hibiscus rosasinensis* at Brisbane

Aceria pongamiae Keifer (New species record for Australia) (Identified by D. Knihinicki)
(M47A) found in galls on leaves of *Pongamia pinnata* at Marrara

Aceria sp. (Confirmed by D. Knihinicki)
(M46A) found in galls on leaves of *Hibiscus tiliaceus* at Marrara

Aceria sp. (Possibly new species) (Confirmed by D. Knihinicki)
(M48B) found in galls on leaves of *Ficus opposita* at Fort Hill Wharf

Acerimina ?tiliaceae Mohanasundarum & Sharma (Identified by D. Knihinicki)
(M46B) found in galls on leaves of *Hibiscus tiliaceus* at Marrara

Eriophyes sp. (Possibly new species) (Confirmed by D. Knihinicki)
(M67) found in galls on leaves of *Terminalia ferdinandiana* at Wildman River

Knorella sp. (New generic record for Australia) (Identified by D. Knihinicki)
(M28 & M75) on leaves of bamboo, *Bambusa arnhemica* at Berrimah Research Farm

?*Leipothrix* sp. (Possibly new species) (Identified by D. Knihinicki)
(M54) on leaf shoots of cypress pine, *Callitris intratropica* at Katherine

Paraphytoptus sp. (New generic record for Australia and possibly new species) (Confirmed by D. Knihinicki)
(M40) on new shoots of *Petalostigma pubescens* at Holmes Jungle, Shoal Bay

Hemisarcoptidae (New NT)

?Hemisarcoptes sp.
(M102) large population feeding on oriental scale (ex fruit of *Carica papaya*) at Humpty Doo

Phytoseiidae

Unknown
(M95A) on *Citrus* sp. at Katherine
(M104) feeding on spider mites (M103) on *Mangifera indica* at Berrimah

Stigmaeidae

Agistermus sp. (New NT)
(M92B) on *Trema tomentosa* at Rooney Shipping, Berrimah

Tenuipalpidae

Brevipalpus californicus (Banks) (New NT)
(M91) on leaves of weed, *Clitoria termalea* at Berrimah Research Farm
(M97A) on *Vigna unguiculata* at Alawa

Brevipalpus ?californicus (Banks) (Confirmed by D. Knihinicki)
(M58) on *Brunfelsia dendifolia* from Thailand at Berrimah

Brevipalpus phoenicis (Geijskes)
(M90) on leaves of orchids, *Dendrobium conanthum* at Berrimah Research Farm
(M94) on fruit of *Citrus paradisi* at Katherine (New host)
(M96) on *Citrus paradisi* at Katherine (New host)
(M97B) on *Vigna unguiculata* at Alawa (New host)

Brevipalpus phoenicis (Geijskes), *B. californicus* (Banks)
(M83) on fruit of *Psidium* sp. at Berrimah (New host)

Tenuipalpus ?pacificus Baker (New NT)
(M99) on orchids, *Vanda* sp. at The Narrows, Darwin

Tetranychidae

?*Eotetranychus* sp. (New NT)
(M85) on weed, *Carthamanus major* at SIL, Berrimah

Eutetranychus orientalis (Klein)
(M107) on *Manihot esculenta* at Milingimbi (New host)

Eutetranychus sp. (New NT)
(M92A) on *Trema tomentosa* at Rooney Shipping, Berrimah

Oligonychus punicae (Hirst) or *O. manigiferus* (Rahman)
(M103) on *Mangifera indica* at Berrimah
(M105) on *Melaleuca* sp. at Katherine (New host)

Oligonychus sp.
(M87) on leaves of *Mangifera indica* at CSIRO, Berrimah

Schizotetranychus ?andropogoni (Hirst) (New NT)
(M101) on grass, *Paspalum notatum* at Katherine

Tetranychus lombardinii Baker & Pritchard (New NT) (Identified by J. Gutierrez)
(unnumbered) on leaves of snake bean, *Vigna unguiculata* at Berrimah Research Farm

Tetranychus urticae Koth (Identified by J. Gutierrez)
(unnumbered) on leaves of eggplant, *Solanum melongena* at Berrimah Research Farm
(unnumbered) on leaves of snake bean, *Vigna unguiculata* at Berrimah Research Farm

Tetranychus sp.
(M100) on potted plant (no name) at Katherine

PROJECT:	**Control of Arthropods and Development of IPM in Tropical Tree Crops**
Project Officers:	**D. Chin, E. S. C. Smith, M. Connolly, H. Brown and G. R. Brown**
Location:	Top End properties

Objective:

Identify potential arthropod problems in mangoes and other tropical tree crops and devise appropriate control measures.

Background:

Mangoes are the most important horticultural crop in the NT and receive a proportionate amount of resources from the Entomology Section. New problems appear each year as this relatively new crop continues to expand in area, production and value, and as new growers enter the production phase. Other commercial tree crops include citrus, rambutan, durian, mangosteen, jackfruit, carambola, guava and cashew. A trial planting recently established by a private company of the Kakadu plum (*Terminalia ferdinandiana*), produced its first yield within the last year.

Horticultural officers, commercial growers and urban backyard producers frequently refer pest problems to the Section for advice or comment and these may help detect new or potentially damaging insect problems. The Section is committed to provide advice and assistance to all growers consistent with the aim of developing integrated pest management (IPM) systems for all tropical tree crops.

Results:

Identification and advice on arthropods were provided to growers, hobby growers and backyard growers on a range of tropical tree crops. During the 2001-2002 period, IPM training and advice on insect identification and monitoring was provided to commercial growers of mangoes, citrus, rambutan and Kakadu plum. Where possible, IPM strategies included regular monitoring of pests and beneficials, and the use of cultural, biological and softer chemical control options. Results from the work on citrus IPM has been included in a separate report.

Mango IPM workshops
Three IPM workshops (two in Darwin and one in Katherine) were provided for growers during 2002. Each workshop was held for a day, either at Berrimah Farm or Katherine Research Station. The workshops included lectures on IPM principles, identification and monitoring of pests and beneficials and cultural, biological and soft chemical control options. Other departmental staff provided lectures on Plant Pathology and Quarantine. Other training sessions involved practical laboratory work on arthropod identification and demonstrations of monitoring in orchards

Pests, diseases and disorders of mangoes in the NT – a field guide
A field guide on the identification of pests, diseases, and disorders of mangoes in the NT was produced in conjunction with Plant Pathology and Horticulture. The publication includes descriptions and life cycles of pests and beneficials, suggested monitoring periods and the effect of pests on the quality and yield. Colour photographs of the damage as well as close-ups of the pests and beneficials are included. The booklet has been designed as a field guide for mango growers and is an easy-to-read reference to aid in the identification of main pests and beneficials for monitoring. The guide also includes suggested methods of cultural, biological and chemical control for an integrated pest management system.

Post-harvest dipping of rambutan fruit with various commercially available oils for the control of insects and mites
A preliminary trial was carried out to test commercially available oils as a post-harvest dip for controlling insects on the surface of rambutan fruit. The treatments were designed to replace the methyl bromide fumigation treatment used on fruit for export to Japan. The trial was carried out in conjunction with Horticulture staff and three rambutan growers. Seven oils (Eco-Oil®, Natrasoap®, Sraytech®, Synertrol®,

Bondtech®, Protec Plus® and Neemtech®) were tested and three of these (Spraytech®, Synertrol® and Protec Plus®) were effective in killing all insects on the fruit.

Kakadu plum (Terminalia ferdinandiana) IPM
Information was supplied to a private company on the identification and monitoring of pests and beneficials on Kakadu plum (*Terminalia ferdinandiana*). Discussion sessions on IPM were held at Berrimah Farm and the plantation at Wildman River was visited to demonstrate insect monitoring techniques. The trees were about three to four years of age and had recently been pruned.

Arthropods recorded during the monitoring session included:

- longicorn beetle – *Platyomopsis* sp. (Coleoptera: Cerambycidae)
- horned tree hoppers – (Hemiptera: Membracidae)
- flatid plant hoppers – (Hemiptera: Flatidae)
- bud mites – (Acarina: Eriophyidae)
- cup moth larvae – (Lepidoptera: Limacodidae)
- leaf caterpillar - (Lepidoptera: Pyralidae)
- leaf miner – (Lepidoptera: Gracillariidae)
- weevils – (Coleoptera: Curculionidae)

Others:

- huntsman – (Arachnida: Heteropodidae)

Diseases:

- leaf spot – *Cercospora terminaliae*

The main entomological problems experienced on the plantation over the past two years were longicorn beetle damage to the trunk and branches; leaf defoliation from caterpillars and swarming beetles and distortion to young leaves caused by mealybugs and mites. No control was carried out however, the level of damage was assessed and recorded by the farm manager. Pest management strategies on the plantation incorporate the use of cultural and organic control methods only.

PROJECT: Development of IPM Strategies for Citrus

Project Officers: M. Connolly, D. Chin, E. S. C. Smith and G. R. Brown

Location: Katherine and Mataranka

Objective:

Identify potential arthropod problems in citrus tree crops and devise appropriate control measures in line with Integrated Pest Management (IPM) strategies.

Background:

Citrus is well suited to the Darwin and Katherine regions with red-fleshed grapefruit, lemons, limes and possibly mandarins having potential for domestic and overseas markets. As at July 2001 there were 70 000 trees planted, with the majority of large plantings now situated near Katherine. However most trees planted in the Top End are still young and over 80% of them have yet to come into production.

The citrus industry requires ongoing research into potential insect pest species, as this relatively new crop continues to expand in area and value. Advice and assistance must also be provided to all growers, consistent with the aim of developing IPM systems.

Methods:

Regular monitoring of citrus plantings in the Katherine region began in December 1999. At this time fortnightly surveys commenced at the experimental cultivar plots located on Katherine Research Station. A further seven private properties in the Katherine region, including one in Mataranka were monitored monthly or at opportunistic intervals.

Due to industry demand, monthly monitoring of five Darwin citrus orchards will commenced in July 2002 and will continue until May 2003. Since the species composition and occurrence of citrus pests is expected to vary slightly between the two regions, monitoring in the Darwin region will be valuable.

In addition to regular monitoring, various small-scale field trials were established between 2000 – 2002 in the Katherine region and these are listed in Table 1.

Table 1. Citrus IPM development field trials established in the Katherine region

Date commenced	Expected completion	Target organism	Control used	Aim
24 January 2000	30 April 2000	Meat ants	Chlorpyrifos granules	Assess chemical efficacy
12 June 2001	22 March 2002	All ant species	Chlorpyrifos impregnated bands	Manage ant activity
5 March 2002	September 2002	Citrus leaf miner	Imidacloprid	Assess chemical longevity
17 May 2002	24 May 2002	Green tree ants	Fipronil ant bait	Assess chemical efficacy
24 May 2002	14 June 2002	Green tree ants	Hydramethylnon and protein baits	Assess bait attractiveness
30 July 2002	March 2003	Red scale	*Aphytis* sp. wasp	Biological control
2 August 2002	March 2003	Red scale and mealybugs	Lacewing species	Biological control

Results:

It is envisaged that regular monitoring will continue until at least May 2003 when collected data may show population trends and allow publication of various new extension materials required by growers. The results of field trials and their implications for crop management will also be reported in May 2003.

PROJECT:	**Management and Control of *Mastotermes* in Northern Australia**
Project Officers:	**B. M. Thistleton, M. J. Neal, H. Wallace and B. Dilley**
Location:	Darwin, Gunn Point, Kowandi Radio Station - Dept of Defence, CPHRS, selected growers properties in Humpty Doo and on the Venn Blocks, Katherine

Objectives:

To develop effective environmentally sustainable control methods against* Mastotermes darwiniensis *that can be applied in horticultural crops by growers or other persons not experienced in termite biology and control.

Assess the effectiveness and test control methods from studies that are being carried out on the biology of the species.

Background:

Mastotermes darwiniensis Froggatt (Isoptera: Mastotermitidae) is the most destructive species of termite in tropical Australia. In the Northern Territory this species accounts for substantial annual production losses in horticultural tree crops and is also responsible for losses in vegetable and agricultural crops. *Mastotermes* can cause major damage to buildings, wooden structures, electrical cables and a variety of other materials. The main chemical registered for use in horticulture against this pest is an organochlorine, mirex. Mirex is the active ingredient of the product Mirant®. With organochlorines being phased out it is necessary that alternative pesticides be tested against *Mastotermes.*

A successful management strategy for the giant termite was developed from research and experimentation conducted during a joint project for the control of *Mastotermes* and reported in previous Technical Annual Reports. The method involves aggregating the termites in 20 litre drums and applying Mirant® to cardboard in the drum. Termites chewing through the cardboard liner either ingest or have some of the gel adhering to their bodies (DBIRD *Agnote* No. I58).

Aggregation drums are the standard technique for research and control of *Mastotermes*. The drums (20 L or 200 L) are filled with pine billets and are placed on soil beside infested trees over the cut stumps of dead trees, or attached to the trunks of infested trees. *Mastotermes* move into these drums in large numbers and these aggregations can then be used for studies on their biology or to test termiticidal activity.

Field testing of several promising insecticides to replace mirex commenced at Coastal Plains Horticultural Research Station (CPHRS) during 1999. One insecticide bait had been shown to give good control, but there had been problems with maintaining the concentration of the active ingredient in the bait and, apart from one small trial (see below), these studies have been discontinued for the time being. However another promising insecticide had been tested in the laboratory and as a soil injection treatment in preliminary field trials in early 2000. Emphasis has been given this year on continued field testing of this insecticide to provide efficacy and residue data for a submission to the National Registration Authority. These studies have been carried in conjunction with the manufacturer of this product. Studies have also been carried out on two other insecticides and on the biology of *Mastotermes.*

Studies on the biology of Mastotermes

Observations on the biology of *Mastotermes* are made at the monitoring sites particularly in the aggregation drums, and by digging nests. In addition, a wood consumption trial to study the feeding behaviour of *Mastotermes*, which had been set up in March 2001 in an area of native bush at Kowandi Radio Station, was continued. Weights of wood consumed over six week intervals were recorded throughout the year, and samples of termites were taken to assess the proportion of each caste.

Colony mapping using fluorescent dyes

Mastotermes darwiniensis nests can be found in the soil and inside trees, but this species does not form mounds and its cryptic habits make it difficult to determine the size of colonies. Previous studies made by CSIRO had used radioactive tracers and fluorescent dyes to map colonies, and the latter technique has been used in the current trial plots. Fluorescent dye has been dusted onto termites in aggregation drums, and this is spread through the colony through grooming and by stomodeal and proctodeal feeding. After a few days samples of termites are collected from other drums and smears of their faeces made on microscope slides. The fluorescent dye particles can be detected by examination of these under a compound microscope using ultra-violet illumination.

This technique was tested in a grid of drums in an old cashew block at CPHRS and has been used in many of the insecticide trial plots. The results are reported in the relevant sections below. Examples of the type of information collected are the demonstration of two colonies close together in a citrus block at Katherine, and one colony covering a distance of 117 metres in an agroforestry block near Berry Springs.

Soil injection trials

The main emphasis this year has been the testing of liquid formulations of one promising product. These have been applied by soil injection, using a Croplands 120 litres electric sprayer with an injection lance, in a range of concentrations and volumes, around the bases of young, non-bearing or mature mango and citrus trees or to the soil underneath aggregation drums. Untreated trees and aggregation drums have been used to monitor the effect of the insecticide at various distances from the application site.

Soil injection on mature mango trees and residue analysis

A soil injection trial to mature mango trees was carried out in Humpty Doo commencing in June 2001. The aim of this trial was to assess the control given by the insecticide and to provide samples of fruit for measurement of residues. Prior to treatment the trees were assessed for termite activity through holes drilled in the trunk and plugged with dowels. Five trees were treated with the product and the trial was assesed four times during the first month and subsequently at monthly intervals. During the first two assessments, sick termites were found in both treated and adjacent trees, indicating the probable effect of the chemical. By the end of June no termite activity was evident in any of the trees within the trial area and the termites had been controlled in the five treated trees and in a further 23 previously infested trees up to 25 metres away. Monitoring continued throughout the year and 12 months after treatment none of the trees had become reinfested.

Samples of fruit were taken weekly from each of the treated trees and a number of adjacent trees between 30 August and 8 November 2001. These samples were frozen and sent to the University of Queensland for residue analysis to support the chemical company's proposed application for registration of the product for this use.

In 2002 a trial will be carried out to assess the effect of this product on mature trees when soil-injected at a lower rate. In April two heavily infested blocks of mangoes at CPHRS (a KP/Sabre block and a variety trial) were chosen for this trial. All trees in both blocks were drilled to assess termite activity and new 4-L paint tins were established on the trunks of some, to aggregate the termites and to allow more detailed observations on their activity. Most of the trees in both blocks were found to be infested and mapping of the colonies was carried out using fluorescent dyes. Three trees in the variety block will be soil-injected in July 2002 and *Mastotermes* activity will be monitored on them and on other trees at varying distances from them. The KP/Sabre block will be monitored as an untreated control.

Soil injection on young mango trees

A trial was carried out in a small infested area of a block of young mango trees at Lake Bennett in October and November 2001. Eight trees were found to be infested and soil injections were carried out on four of them. Termite activity ceased in all the four treated trees as well as in the other four non-treated trees.

Soil injection on young citrus trees

A soil injection trial was carried out in two plots of 960 young citrus trees in Katherine. On one block, ten 20 L aggregation drums were established between October and December 2001 and fluorescent dye studies demonstrated that there were two colonies of termites. In December 2001 soil injections were carried out on every third tree in every second row of this plot. In January, one month after application, all of the 960 trees were checked for new activity but none was found. Several of the aggregation drums had become inactive and the termites in the others were sick and covered with parasitic mites. At the six month assessment all trees were free of termites, although a few of the aggregation drums still had populations of sick termites, mainly mite infested pseudergates with few or no soldiers.

While the size of *Mastotermes* colonies makes it impractical to carry out fully replicated trials, the second block of 960 trees was used as an untreated control. Termite activity continued in the trees and the number of trees infested had increased by the six-month assessment. Several drums were also established on this block and all were active and healthy throughout the period of the trial, with both pseudergates and soldiers present and low numbers of parasitic mites.

This second block was then used for a second trial using soil injection at a different rate, which commenced in June 2002.

Soil injection under drums in agroforestry and garden blocks
A number of trials detailed below were carried out in agroforesty blocks. In each of these a number of infested trees were cut down and 20 L aggregation drums were set up on the stumps. Once there was activity in the drums, soil injections were carried out on the soil under some of them and the rest was used for monitoring purposes.

Eight 20 L aggregation drums were set up on each of two agroforestry blocks (Howard Springs and near Berry Springs) in August 2001 and soil injections were carried out under two drums at each site. Each treated drum had untreated drums at varying distances and at both sites activity in all the untreated drums ceased within a few weeks. At the Howard Springs site, the furthest non-treated drum was 37 metres from a treated drum, while at the other site the distance was 16 m.

Four more aggregation drums were set up in the Berry Springs agroforestry plot to bring the total to 12 in four groups covering a total distance of 117 metres. Fluorescent dye studies established that termites in these drums were all part of the same colony. Soil injections were carried out on various drums within this plot to establish how far the effect of the toxicant would spread.

Five 200-L drums were set up in a garden at Humpty Doo where ornamental and mango trees were drilled and assessed for termite activity. The drums were initially used to test a dust formulation of the insecticide mixed with *Eucalyptus regnans* flakes, which proved to be a repellent. The soil under the drums was then injected. Activity initially ceased in trees up to 40 metres from the drums. Later, activity resumed in some of the distant trees possibly due to incursions from an adjacent colony in a neighbouring property. After further treatment of the reinfested trees and some of the trees along the fence-line in the other property, termite activity ceased.

Baits
A small trial was carried out using a commercial bait formulation placed in two active 200-L drums at CPHRS. The insecticide had been previously tested in laboratory manufactured baits and had been highly attractive to termites. Control had been successful, but the trials were discontinued due to problems of maintaining correct concentrations of the insecticide in the bait. This problem was solved in the commercial baits, but they had been developed for other termite species and proved to be unattractive to *Mastotermes*.

Trials were commenced with another bait incorporating an insecticide, which inhibits the production of chitin and prevents development of the termites. This bait was applied to aggregation drums in a plot of *Pinus caribaea* at Gunn Point. *Mastotermes* activity was assessed regularly using more aggregation drums and grids of billets. The trial is continuing.

Extension
Advice was frequently given on *Mastotermes* control, in most cases by visiting the grower but also by providing Agnotes and the booklet on aggregation techniques. Two Agnotes, which dealt with management of termites in rural blocks and home gardens respectively, were revised and republished as a single Agnote No. I58 entitled "Management of the Giant Termite."

Collaborative Research
Assistance was given to visiting termite researchers from the CSIRO, Japan, Belgium and France on studies of *Mastotermes* and other termites in the NT. Joint termite studies are being carried out with the Department of Agriculture, Western Australia, and workers from Kununurra came for consultations. New products are being tested for insecticide companies and representatives have visited Darwin for discussions.

PROJECT: Peanut Entomology

Project Officers: M. Connolly and G. R. Brown

Location: Katherine and Douglas Daly

Objective:

To sample and identify insect species found on peanut crops and to determine their pest status.

Background:

Peanuts, *Arachis hypogaea* L. (Fabaceae), are a high value, high input legume crop. This is the second year of a three-year project where intensive insect sampling has taken place at two grower properties. One is located about 40 km south west of Katherine and the other is in the Douglas Daly Basin. The Douglas Daly grower has planted two pivots with peanuts for five years consecutively whilst the Katherine grower will make his second harvest at the end of the 2002 growing season.

Method:

Beginning in April and continuing until harvest, the Katherine property was sampled each fortnight and the Douglas Daly property monthly. During each field visit, samples were taken from five random locations around the pivot circles. At each site 10 m of crop row was vacuum sampled and 2 m visually checked. Vacuum samples were sorted into pest and beneficial species and absolute numbers noted. At dates closer to crop maturity several plants were dug from five random locations to check for pod damage. Any new insect pests or live specimens that were collected or reared were lodged in the NT economic insect collection.

Results:

As the cropping season did not conclude until October, only partial results are currently available. Complete results, together with consecutive years of data will be published in the 2003 TAR. The following is an overview of insect activity compared to last year's observations. Beneficial insects are not discussed.

Unlike 2001, sucking bugs, including the green vegetable bug, *Nezara viridula* (Linnaeus) and the red-banded shield bug *Piezodorus hybneri* (Gmelin) (Hemiptera: Pentatomidae), were almost completely absent from the crop canopy. One species of leafhopper *Austroasca alfalfae* (Evans) (Hemiptera: Cicadellidae) was again abundant, with the presence of nymphs indicating breeding activity. Despite high numbers of *A. alfalfae,* typical leaf feeding damage normally associated with leafhoppers was not observed. The brown mirid, *Creontiades pacificus* (Stål) (Hemiptera: Miridae) and its nymphs were collected but not considered to be at levels capable of causing economic damage.

Helicoverpa spp. (Lepidoptera: Noctuidae) larvae were present for most of the crop's cycle and have proven to be especially damaging at flowering when they tend to feed on flowers instead of foliage. *Helicoverpa* pressure was very high at the Douglas Daly site in early May. *Spodoptera litura* (Lepidoptera: Noctuidae) larvae were again found at the Katherine site in late June where they fed on developing peanut pegs before they reached the soil, thus resulting in a loss of yield.

Adding to last year's collection, a variety of geometrid, noctuid and other unidentified larvae were found in and below the crop canopy. Few species of collected larvae fed on fresh peanut kernels when offered as food in the laboratory. Identifications of these species are under way. No lucerne seed web moths, *Etiella* *behrii* (Zeller) (Lepidoptera: Pyralidae) were seen in any samples from either property. However a small amount of damage was found that was characteristic of internal feeding by a caterpillar, leaving only an exit hole.

Several species of false wireworm (Coleoptera: Tenebrionidae) have proven to be damaging to the germinating stages of various horticultural and field crops in the region. One type of damage noted on immature peanut pods is characterised by 'scarifying' on the outer shell of the peanut and in some cases holes are made through the shell causing kernels to rot out. This 'scarifying' damage has been replicated in the laboratory using larvae of the false wireworm beetle, *Gonocephalum carpentariae* Blackburn. Another species, *Caedius sphaeroides* Hope, although found at the edges of peanut fields, has not been associated with any type of feeding damage.

PROJECT: Sesame Entomology

Project Officers: M. Connolly and G. R. Brown

Location: Katherine

Objective:

To survey insects found on sesame crops and to identify pest and beneficial species.

Background:

Sesame, *Sesamum indicum* L. (Pedaliaceae), is well adapted to the semi-arid tropical regions of the world and is cultivated for use in confectionery, culinary items and cosmetics. Although it has the potential, sesame has been grown only irregularly as a commercial crop in the NT.

Sesame is a rain-fed crop grown over the wet season and recently trial plots have been grown at Douglas Daly Research Station and Katherine Research Station. There were no commercial crops available to sample in the 2001/2002 growing season.

There are no native species of sesame present in the NT, although there are stands of roadside feral sesame in the Katherine and Douglas Daly regions. These are a potential source of insect pests that may spread to commercial crops.

Method:

Feral sesame was vacuum-sampled and visually assessed for insect damage at five sites in the Katherine area. Sampling occurred fortnightly from 27 November 2001 to 21 January 2002. These sites were:

Site 1 – Gorge Road, 2 km past the Kumbidgee turn off.

Site 2 – Old Katherine Airstrip, Gorge Road.

Site 3 – End of Callistemon Drive, Katherine, (in bushland).

Site 4 – Martin Terrace, Katherine East, behind the Salvation Army community centre.

Site 5 – Corner of Crawford and Palmer Streets, Katherine (in bushland).

On 8 February, 10 individual plants from each site were randomly selected for harvest.

Sesame trial plots at Katherine Research Station were occasionally observed for insect activity. Additionally larvae of the sesame leaf roller, *Antigastra catalaunalis* (Dupont), (Lepidoptera: Pyralidae), were collected to observe parasitic activity.

Results:

Vacuum samples have been sorted but data is not available for this report. A third and final data set will be compiled from the 2002-2003 growing season then comparisons will be drawn in a final report.

Similar to last season, the most abundant insect families were leafhoppers (Hemiptera: Cicadellidae), mirids (Hemiptera: Miridae) and plant hoppers (Hemiptera: Fulgoroidea), and the high numbers of nymphs from these groups indicated that they were breeding on the sesame.

One species of mirid, *Nesidiocoris* nr *tenuis* (Reuter) was extremely abundant on feral sesame plots during November and December. Sites with high mirid populations developed leaf mottling and leaf distortion on young plants less than 50 cm tall. *N.* nr *tenuis* is normally recorded from solanaceous and capparaceous plants and is considered an economic pest on tobacco. However, these insects are also facultative predators and their pest status on sesame is not known. This insect also became abundant on plots at the Katherine Research Station during March 2002.

Unlike the trial plots, feral sesame sites suffered little damage from *Helicoverpa* spp. (Lepidoptera: Noctuidae), *Nezara viridula* (Linnaeus), (Hemiptera: Pentatomidae) nor *A. catalaunalis*. However, one family of grasshopper (Orthoptera: Pyrgomorphidae) was extremely abundant at some feral sesame sites causing nearly complete defoliation, as well as chewing flowers and seedpods. A species of hawk moth larvae, *Agrius ?godarti* (Macleay), (Lepidoptera: Sphingidae) was found defoliating plants at the Katherine airstrip site.

Similar to last season's results, the majority of insects found were not pests. Instead, it is presumed they are attracted to the flowers. These include a wide range of beetles (Coleoptera), flies (Diptera) and ants, bees and wasps (Hymenoptera), although some of the latter could also be predators or parasites of pest species. The most abundant group of predators was spiders.

Parasitism of *A. catalaunalis* by wasps (Hymenoptera) was greatest in year 2001. The wasp species have not been identified. A species of parasitic mermithid nematode was identified as *Agmermis* sp. nr. *catadecaudata,* Baker and Poinar. The presence of this nematode is interesting as all previous published records are from the Northern Tablelands in New South Wales and the only other host species known in Australia are grasshoppers (Orthoptera). Other mortality factors of field collected larvae included the failure to pupate and larval death due to bacterial or viral infection.

Table 1. Summary of *Antigastra catalaunalis* larvae parasitism and mortality from field collected specimens

	21-Feb 2000	21-Feb 2001	15-Feb 2002
Larvae (n)	22	27	41
Wasps (%)	5	44	5
Nematodes (%)	18	nil	46
Other (%)	14	19	41

PROJECT: Pest Management in Tropical Vegetables

Project Officers: B. M. Thistleton, E. S. C. Smith, M. J. Neal and H. Brown

Location: Darwin area

Objective:

To advise on resistance management for the major pests of tropical vegetables and to conduct research using natural enemies and lower toxicity pesticides to enhance control.

Background:

Poinsettia whitefly, *Bemisia tabaci* Type B (Hemiptera: Aleyrodidae), melon thrips *Thrips palmi* Karny (Thysanoptera: Thripidae) and two spotted mite (TSM), *Tetranychus urticae* Koch (Acarina: Tetranychidae), are the most serious pests of tropical vegetables in the Darwin area. All three species exhibit resistance to a greater or lesser extent to most of the currently commercially available pesticides and outbreaks are generally linked to the use of persistent chemicals. Other pests are more specific to particular crops (e.g. beanfly *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae on snake beans) or can be controlled with more specific pesticides (e.g. melon and cowpea aphid control with pirimicarb).

There is a range of natural parasites and predators which are effective against these pests, provided that non-disruptive chemicals are used to prevent excessive mortality of the natural enemies. In addition, the commercially produced Chilean predatory mite, *Phytoseiulus persimilis,* Athias-Henriot (Acarina: Phytoseiidae) can be introduced to bring TSM populations under control.

Results:

Visits were made to growers' properties to assess pest populations and advise on control measures. Advice was also given to enquiries made by telephone.

A trial was carried out to evaluate a product for the control of ginger ants, which were causing damage to melon seeds. The product gave good control of the ants. The company is intending to apply for registration of this product as a general ant bait, which will include the above tested use.

A proposed trial to test alternative products to dimethoate for control of beanfly was reviewed and, in addition to spinosad and imidacloprid, it is proposed to test petroleum spray oils, which may affect oviposition. This trial will be carried out in 2003.

Posters were prepared on pests of cucurbits and, in conjunction with the Horticulture Branch, pests of tropical vegetables.

SUBPROGRAM: Interstate Quarantine

PROJECT: Provide a Government Certification System as an Alternative to Interstate Certification Assurance (ICA) for Market Access of NT Produce

Project Officers: **J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross, B. Dilley, I. Haselgrove, R. Smith, A. Jacks and S. Chester**

Location: Darwin, Katherine and Alice Springs

Objective:

To enable market access of NT produced plant material to other States of Australia, quarantine officers from the Department of Business, Industry and Resource Development (DBIRD) provide Plant Health Certificates specifying that conditions of entry have been met.

Background:

NT produce (fresh fruit and vegetables, cut flowers, nursery stock) consigned to States which have quarantine entry requirements must be certified by either plant health certification or ICA that these requirements have been met. Most producers have opted for ICA accreditation where an approved arrangement has been developed to enable certification. Where ICAs are not available for a particular product, or consignments are irregular or few in number to make an ICA option economic, DBIRD may provide a plant health certificate based on inspection or other procedures.

Nationally agreed ICA arrangements for cut flowers and nursery stock have not been developed, or are not yet approved. Appointments are therefore required by these industries for departmental inspection and government certification prior to consignment to States where entry restrictions exist.

Method:

To enable interstate movement of cut-flowers and nursery stock, NT Quarantine Section (NTQS) staff are required to inspect each consignment and certify it as meeting the receiving States' entry requirements.

All nurseries and cut-flower suppliers consigning to Western Australia are monitored for melon thrips (*Thrips palmi*), spiralling whitefly, western flower thrips and mango leafhopper to meet this particular certification requirement.

Businesses accredited under ICA and consigning to some states must also receive an inspection of their produce by NTQS, followed by official endorsement on their documents showing the produce to have been inspected and found to be free of a number of pests not covered by ICA arrangements.

Results:

A total of 841 plant health certificates were issued during the financial year to 30 June 2002 and a total of 324 endorsements were made on ICA documents. These figures combine to a total of 1165 appointments, or an average of 97 per month throughout the year.

PROJECT: **Market Access for NT Produce under Approved Interstate Certification Assurance (ICA) Arrangements**

Project Officers: **J. Swan, P. Cawdrey, A. Mullins, S. Chester, J. Lindsay, R. Smith and A. Jacks**

Location: Darwin, Katherine and Alice Springs

Objective:

To maintain market access of NT horticultural produce within Australia under approved ICA arrangements.

Background:

ICA is a system of plant health certification based on quality management principles. ICA provides an alternative to traditional plant health certification involving the Department of Business, Industry and Resource Development (DBIRD) inspectors. Traditionally inspectors supervised treatment and/or inspected produce and issued plant health certificates for the movement of produce intrastate or interstate.

Under ICA, a business can be accredited to issue plant health assurance certificates for its produce. To be accredited, a business must be able to demonstrate it has effective in-house procedures in place that ensure produce consigned to intra and interstate markets meet specified quarantine requirements.

Method:

ICA is based on documents. Operational procedures are developed by DBIRD in conjunction with industry and interstate quarantine authorities. Operational procedures describe the management system and process controls that must be implemented and maintained by a business to become accredited to certify that a specific quarantine treatment has been met.

Under an ICA arrangement, the accredited business assumes responsibility for specified treatments and/or inspections previously undertaken by DBIRD inspectors. DBIRD must ensure the ICA arrangement is in place and working effectively through a program of regular audits.

Once accredited, a business is able to issue documents known as plant health assurance certificates that are accepted by DBIRD and the plant quarantine authorities of other States as evidence of conformance to the specified quarantine requirements covered by that certificate.

Results:

Operational procedures have been developed for a range of treatment and condition requirements including:

- dipping
- flood spraying
- low volume non-recirculating spraying
- fumigation
- heat treatment (vapour heat and hot water)
- cold treatment
- hard green/mature green/unbroken skin condition
- pre harvest treatment and inspection
- splitting and reconsigning certified produce

Over 600 arrangements are currently being utilised by over 300 businesses in the NT.

Further operational procedures will be developed as the needs arise.

PROJECT: **Provide a Screening Process for Imported Plant Material for the Presence of Pests and Diseases**

Project Officers: **J. Swan, I. Haselgrove, P. Cawdrey, B. Dilley, A. Mullins, J. Lindsay, R. Smith and A. Jacks**

Location: Territory wide

Objective:

To ensure that any plant material entering the NT from other regions of Australia complies with movement conditions under NT legislation.

Background:

The local horticultural industries are advantaged by reduced production costs and better market opportunity where the NT is free from pests and diseases occurring in other regions of Australia.

Plant material (fresh fruit and vegetables, cut-flowers and nursery stock) entering the NT must comply with legislation and have accompanying certification that these requirements have been met.

The NT accepts plant health certification and interstate certification assurance (ICA).

Method:

An ongoing inspection program is maintained at NT florists, nurseries and fresh fruit and vegetable importers to inspect produce from risk areas of Australia.

Targeted pests include western flower thrips, spiralling whitefly, Mediterranean fruitfly, banana fly, cucumber fly and red imported fire ant (RIFA).

The NT targets RIFA as a particularly serious environmental and agricultural pest and high-risk materials which may harbour this pest are routinely inspected on arrival.

The NT Quarantine Branch utilises the detector dog service for surveillance and to increase public awareness of the risks of introducing pests and diseases on plant material.

Results:

The NT has maintained freedom from these targeted pests.

PROJECT:	**Provide an Inspection Service under NT Legislation for Shipping Containers from Giant African Snail (GAS) Infested Countries**
Project Officers:	**J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross and B. Dilley**
Location:	Darwin

Objective:

To provide prompt and efficient quarantine clearance and or subsequent treatment of goods originating from GAS infested countries identified under NT legislation.

Background:

GAS is considered by most authorities to be the world's most damaging land snail. It is known to attack over 500 plant species including legumes, cucurbits and many other vegetables as well as a wide range of tropical ornamentals. GAS has long been a concern to the NT due to its presence in all countries in SE Asia and the ease of transfer of snails or snail eggs by shipping containers.

The Australian Quarantine Inspection Service (AQIS) does not include Indonesia (and some SE Asian Countries) in the high-risk GAS areas on the basis that the risk of GAS infesting cargo in the few main ports of large cities en-route to Australia is low.

The Territory, however, has different shipping links to Indonesia than other areas of Australia and may receive cargo from other minor ports where the risk of GAS being present is much greater.

GAS has been added to the NT notifiable pest list.

Method:

Containers identified as imported from GAS areas, which would be released by AQIS but are identified in NT legislation, are considered to be a quarantine risk. The imported break-bulk cargo containers and their contents may be contaminated with quarantine risk materials such as GAS and soil. Containers are unpacked under the supervision of an NT quarantine inspector. When a quarantine risk material is intercepted during inspection the cargo/container is referred to AQIS.

Results:

NTQS and contract personnel inspected a total of 306 containers during the year for GAS. Considerable break-bulk cargo was additionally inspected.

No infestations of GAS were detected. However 67 were referred to AQIS for quarantine action. Quarantine risk items detected included: seed contamination, live insects, bark, maggots, bone, feathers, grass and beans.

PROJECT:	**Exotic Fruit Fly Monitoring**
Project Officers:	**I. Haselgrove, B. Dilley, J. Peart, A. Jacks, R. Smith, E. Conway, J. Starr and D. Salter**
Location:	Territory Wide

Objective:

The early detection and timely identification of exotic and interstate (Medfly) fruit flies.

Background:

Monitoring for pest species of fruit flies occurring interstate and overseas is carried out on a fortnightly basis during the dry season and more frequently over the wet season in the Darwin area.

Further monitoring grids are located throughout strategic urban areas and across the great majority of horticultural production areas of the NT.

Early detection of pest species is extremely beneficial for both the feasibility and cost of eradication.

Method:

Three lure types are used, ME (Methyl Eugenol), CUE (Cuelure H) and MED (Capilure R). The areas surveyed and number of traps in each are as follows:

Trap areas:

Area	ME	CUE	MED
Darwin and rural Darwin	50	9	20
Katherine	17	0	9
Tennant Creek	4	4	0
Borroloola	2	0	0
Ti Tree	5	19	5
Gove	4	4	2
Alice Springs and rural Alice Springs	21	65	16

Lures are assembled in Darwin and dispatched to the regions monthly.

All specimens collected from traps are sent to the Darwin office for identification.

Results:

A single male specimen of the exotic fruit fly *Bactrocera philippinensis* was detected in August 2001. An extensive grid of traps was then established and maintained for a period of 8.5 months. The NT was placed on ‘alert’ stage of an exotic pest outbreak during this period. No further flies of this species were trapped and as a consequence an outbreak situation was not declared and the ‘all clear’ was declared at the end of April 2002.

PROJECT: Provide Responses to Incursions of New Pests and Diseases

Project Officers: **J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross, B. Dilley, I. Haselgrove, A. Jacks and R. Smith**

Location: Any area within the NT

Objective:

To provide a timely response to incursions of new pests and diseases which would increase the feasibility of eradication and minimise the potential costs of these incursions.

Background:

The Northern Territory has the potential to be the first place of entry for both interstate and international exotic pests and diseases that can affect the horticulture and agricultural industries and the community. Experience has proven that early detection and rapid responses can increase the feasibility of eradication and greatly reduce the financial costs involved.

Method:

A situation report of an incident would trigger the involvement of a specialist who can identify a potential new pest or disease. The report must be confirmed and notification be given to appropriate senior staff, legal officers, ministerial staff, specialist interstate plant pest/disease committees, Commonwealth and State authorities.

Management team structures and tasks are established and the incident is managed according to the Departmental Response Plan, November 2000.

The NT Quarantine Section generally has an early involvement in the investigation of the incident, and provides containment operations, resourcing and assistance to develop procedures to maintain market access of plant products where this may be affected.

Result:

The NT Quarantine Section was involved in four major incidents relating to exotic pest and disease incursions during the year:

- Potato spindle tuber viroid (May 2002). A suspect detection of this serious disease on hydroponic tomatoes affected one supplying nursery, four commercial growers and some backyard producers supplied through a local retail outlet. Further testing revealed a mis-identification of the disease by an interstate diagnostic laboratory.

- Exotic fruit fly (*Bactrocera philippinensis*) (August 2001). This detection was described in the section on exotic fruit fly monitoring.

- Daylily rust (*Puccinia hemerocallidis*) (November 2001). The disease was detected for the first time in Australia in Brisbane on a small number of properties producing commercial daylily plants, some of which were exported interstate. Control and containment measures were applied and several other detections were subsequently made in SE Queensland. No detections of the disease were made in other States/Territories following national surveys.

- Grapevine leaf rust (caused by *Phakopsera euvitis*) (July 2001). Symptoms of grapevine leaf rust were noticed on leaves of a grapevine growing in a Darwin backyard. In the Darwin, Palmerston and rural area 247 vines have been inspected and 47 were detected with rust. An eradication program may be mounted against this disease.

PROJECT: Dissemination of Information

Project Officers: **J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross, B. Dilley, I. Haselgrove, R. Smith, A. Jacks and S. Chester.**

Location: Territory Wide

Objective:

Provide relevant information and awareness to industry and the general public of movement conditions and methods of meeting certification requirements for the movement of plant material into and out of the NT.

Background:

The section is responsible for keeping industry and the public well informed of quarantine movement requirements for plant material between regions of Australia.

Various arrangements have been developed under an interstate certification assurance system, approved nationally for market access of plant material. Advice regarding this and the alternate Government Certification methods are provided.

The section provides advice to importers and brokers of procedures for prompt and efficient quarantine clearance and or subsequent treatment of goods originating from the giant African snail (GAS) countries identified by NT legislation.

Method:

- Telephone enquiries from both industry and the general public on movement conditions of goods.
- Training packages delivered to industry and staff on correct methods of meeting requirements.
- Attendance at meetings both locally and interstate to maintain up-to-date information and discuss and recommend new plant access requirements. This information is also distributed to industry bodies after approval at Interstate Plant Health Working Committee level.
- Routine attendance at regional shows to highlight current issues and disseminate information.
- Production of timely reference documentation and distribution to industry through mail and personal visits when required.

Results:

- During the year, more than 2,000 telephone enquiries were processed for the general public and industry.
- Attendance at growers properties, nurseries, florists, fresh fruit and vegetable outlets on a routine basis to check compliance and advise on new conditions.
- Considerable in-office enquiries or appointments for the general public and industry. More than 600 arrangements are currently utilised by over 300 businesses in the NT. All are maintained on the database, *Plant Health Information System*.

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